

105th Congress, 1st Session - - - - - House Document 105-17

GUANAJIBO RIVER, PUERTO RICO

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY

(CIVIL WORKS)

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY DATED FEBRUARY 27, 1996, SUBMITTING A REPORT TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS—RECEIVED IN THE UNITED STATES HOUSE OF REPRESENTATIVES NOVEMBER 12, 1996, PURSUANT TO SECTION 204 OF THE 1970 FLOOD CONTROL ACT (PUBLIC LAW 91-611)



JANUARY 7, 1997.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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WASHINGTON : 1997

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LETTER OF TRANSMITTAL



DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

0 6 NOV 1996

REPLY TO
ATTENTION OF

Honorable Newt Gingrich
Speaker of the House
of Representatives
Washington, D. C. 20510

Dear Mr. Speaker:

In final response to Section 204 of the 1970 Flood Control Act, and to resolutions adopted by the Senate Committee on Environment and Public Works and the House Committee on Public Works and Transportation on March 26, 1982, and September 23, 1982, respectively, the Secretary of the Army recommends authorization of a flood damage reduction project for the Rio Guanajibo, Puerto Rico. The proposal is described in the report of the Chief of Engineers dated February 27, 1996, which includes other pertinent reports and comments.

The views of the Commonwealth of Puerto Rico; the Departments of the Interior, Transportation, and Agriculture; and the Environmental Protection Agency are set forth in the enclosed communications.

The recommended plan maximizes net national economic development benefits consistent with environmental quality. The plan consists of two separable elements. The Mayaguez-Hormigueros separable element includes two components with a total length of about 3.9 miles of levees and floodwalls. The levees and floodwalls at the Guanajibo Homes and San Jose areas would have a length of about 2.0 miles, an average height of about 15.5 feet, and would provide about a 200-year level of flood protection. The levees at Valle Hermoso and Buenaventura areas would have a length of about 1.9 miles, an average height of about 14.0 feet, and would provide about a 125-year level of flood protection. Based on October 1995 price levels, the first cost of the Mayaguez-Hormigueros separable element is estimated at about \$19.0 million. Based on an interest rate of 7-5/8 percent and an economic life of 50 years, this element would provide average annual benefits of about \$5.5 million, have an average annual cost about \$1.6 million, and a benefit-cost ratio of 3.4.

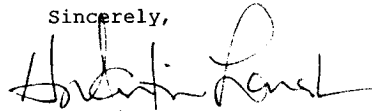
The separable element for the San German area consists of about 1 mile of channel modification and replacement of the Puerto Rico Highway 119 bridge. These improvements would provide about a 10-year level of flood protection. Based on October 1995 price levels, the first cost of the San German separable element is estimated at about \$8.0 million. Based on an interest rate of 7-5/8 percent and an economic project life of 50 years, this element would provide average annual benefits of about \$0.88 million, have an average annual cost of about \$0.71 million, and a benefit-cost ratio of 1.2.

No fish and wildlife mitigation is required for the recommended San German element. However, the adverse impacts to mangrove habitat due to construction of the Mayaguez-Hormigueros element must be mitigated. The recommended mitigation plan consists of acquiring 27.6 acres of land near Cano Corazones Creek and the Guanajibo Homes development and planting replacement mangroves.

In accordance with Section 202(a) of the Water Resources Development Act of 1996, the minimum non-Federal costs for the flood damage reduction project should be 35 percent. Based on October 1995 price levels, the project has a first cost of \$27,000,000 of which about \$17,550,000 would be Federal and about \$9,450,000 would be non-Federal. In addition, non-Federal interests would be required to implement a floodplain management plan for the project area.

The Office of Management and Budget advises that there is no objection to the submission of the report to the Congress. A copy of its letter is enclosed in the report.

Sincerely,

A handwritten signature in dark ink, appearing to read "H. Martin Lancaster", is written over the typed name.

H. Martin Lancaster
Assistant Secretary of the Army
(Civil Works)

**COMMENTS OF THE OFFICE OF MANAGEMENT AND
BUDGET**



EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503
September 23, 1996

The Honorable H. Martin Lancaster
Assistant Secretary of the Army
for Civil Works
Pentagon - Room 2E570
Washington, DC 20310-0103

Dear Mr. Lancaster:

As required by Executive Order 12322, the Office of Management and Budget has completed its review of your February 27, 1996 report on Guanajibo River, Puerto Rico.

The Administration supports authorization of this project for construction in accordance with your recommendation. The Office of Management and Budget does not object to your submitting this report to Congress.

Sincerely,

A handwritten signature in black ink, reading "T.J. Glauthier", is positioned above the typed name.

T.J. Glauthier
Associate Director
Natural Resources,
Energy, and Science

COMMENTS OF THE COMMONWEALTH OF PUERTO RICO



COMMONWEALTH OF PUERTO RICO
OFFICE OF THE GOVERNOR
PUERTO RICO PLANNING BOARD

Minillas Governmental Center, North Bldg.
De Diego Ave, Stop 22
P. O. Box 41119, San Juan, P. R. 00640-1119

March 3, 1995

A. J. Salem, Chief
Planning Division
Department of the Army
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232


Dear Mr. Salem:

The purpose of this letter is to clarify the Puerto Rico Planning Board's position with respect to the Rio Guanajibo flood control project. After reviewing the final feasibility report, we fully support the recommended plan in the feasibility report which calls for the construction of levees in the Mayagüez-Hormigueros area to protect developed areas from the 100-year floods event and the channel improvement in San German to protect the vicinity of the town against the 10-year flood event.

In this latter case, we see that the feasibility report examined several designs including levees and channels for the 100-year events, but they are not economically justified. This letter supersedes our letter of August 24, 1994.

Thank you very much for the opportunity of commenting on this needed project for the southwestern part of Puerto Rico.

Cordially,



Norma E. Burgos-Andújar
Chairwoman

BAM/RMM/aha

COMMENTS OF THE DEPARTMENT OF THE INTERIOR



United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

JAN 27 1995

ER 94/860

Mr. Donald A. Banashek
Chief, Policy Review Branch, HQUSACE
ATTN: CECW-AR (SA)
7701 Telegraph Road
Alexandria, VA 22315-3861

Dear Mr. Banashek:

The Department of the Interior has completed its review of the proposed Chief of Engineers report; other pertinent reports; and Final Environmental Impact Statement on Flood Control for the Rio Guanajibo and Tributaries in the Vicinity of Mayaguez, Hormigueros, and San German, Puerto Rico.

General Comments:

Our Fish and Wildlife Service (FWS) has been coordinating with the Army Corps of Engineers on this project for several years. The project has changed significantly, and impacts to wetlands have been reduced. The FWS will continue to discuss mitigation options with the Corps.

Specific Comments:

Final Environmental Impact Statement (FEIS), Exhibit V,
Mitigation Plan:

The Corps proposed mitigation plan consists of the acquisition of 27.6 acres of land to be leveled to the surrounding mangrove elevations and seeded with mangrove vegetation.

The Corps FEIS also mentions possible habitat enhancement opportunities in the proposed borrow site. The area could be graded in such a way as to expand the existing Merle Marsh or as an experimental forested wetland. While we do not object to these plans, we recommend that the Corps consider an alternative site within the project area.

This site is a forested wetland located between the Ramirez de Arellano and San Jose Estates residential developments. The wetlands are comprised of red mangroves, Pterocarpus, and basin black mangroves. Most of this area is designated as "dense woods" in the current Corps maps; an exact acreage figure is not available at this time. These wetlands have been impacted by

X

changes in hydrology, past agricultural practices, and burning. The area provides an excellent opportunity for a multi-system restoration, with a better than average probability for success. The area also lends itself to the creation of a wetland interpretive center and possible wildlife education area. We believe that this site presents excellent mitigation and restoration opportunities and should be considered by the Corps in their final mitigation plans. If you need any further information on the details of our alternative mitigation site, please contact Mr. James P. Oland of the FWS Caribbean Field Office at 809/851-7297.

We appreciate the opportunity to comment on these documents.

Sincerely,

A handwritten signature in dark ink, reading "Willie R. Taylor". The signature is written in a cursive, flowing style. The first name "Willie" is written with a large, prominent "W". The last name "Taylor" is written with a large, prominent "T". The middle initial "R." is written in a smaller, more compact style between the first and last names.

Willie R. Taylor
Director
Office of Environmental Policy
and Compliance

COMMENTS OF THE DEPARTMENT OF AGRICULTURE



United States
Department of
Agriculture

Soil
Conservation
Service

Caribbean Area
PO Box 364868
San Juan, PR 00936

Subject: ECS - Environmental Impact Statement

Date: November 16, 1994

To: Mr. John E. Frost, Budget and Special Studies
Coordinator
Watershed Projects Division

Enclosed is a copy of recommendations previously submitted
regarding the Draft Feasibility Report and Draft Environmental
Impact Statement for the Rio Guanajibo project.

Carmen Hastings for
ROY L. VICK
Staff Soil Scientist



United States
Department of
Agriculture

Soil
Conservation
Service

Caribbean Area
P.O. Box 364868
San Juan, PR 00936-4868

September 15, 1994

Mr. A.J. Salem
Chief, Planning Division
Environmental Branch
U.S. Army, Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Dear Mr. Salem:

This letter is in regards to your request for information regarding the Revised Draft Feasibility Report and Draft Environmental Impact Statement for the Rio Guanajibo project. I have reviewed the document for technical accuracy on references to soils. The following are requested corrections and comments:

- Page 22: 5. Soils. "porus" is spelled "porous". Coloso series should read "somewhat poorly drained".
- Page 28: C. Land Use. The acreage of wetlands is high and does not agree with Table 6. Also, see comments on page 105 and Figure 4-1.
- Page 42: F. Sediments. The Soil Conservation Service is abbreviated SCS, not USSCS.
- Page 105: Coloso soils are NOT on the hydric soils list. The Coloso map unit is listed as one that may have hydric inclusions. Coloso soils do exhibit anaerobic characteristics, but are somewhat poorly drained and do not have a water table for sufficient duration near the surface to qualify as a saturated hydric soil. If some areas of Cn pond or flood for sufficient duration, then those specific areas could be considered hydric. I believe this would be unlikely for entire delineations of Cn. Tidal swamps (Td) and Alluvial land (An) ARE on the hydric list as hydric soils. I suggest replacement of Figure 4-1 with something reasonable such as I have enclosed.



Page 143: Soils. I would be interested in Mr. Garcia's evaluations that led him to classify Coloso as hydric on the basis of color. Ponding is so far the only criteria that will place Coloso as a hydric soil.

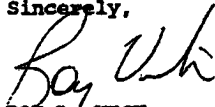
Page 144: 5. If "all areas mapped as Coloso soils (Cn) are actively planted and maintained as sugarcane are not currently functioning as wetlands", then they are NOT wetlands. They may meet the FSA criteria as PC - Prior Converted Cropland, if they could be proven to have ponded prior to farming. If not, then they are non-wetlands (NW) or uplands.

Page 145: Site 2, etc. Same comment on soils colors of Coloso as page 143. These colors are not indicative of hydric soils.

Page 264: D. Soils. The hydrologic group for Toa is B, Coloso (not Calosa) is D. Mucara, not Macara.

If requested, we will assist in evaluating the agricultural lands for an official wetland determination. The report states using the 1989 manual for the evaluations. Considering this and the previous errors cited, a new evaluation is indicated.

Sincerely,



ROY L. VICK
Staff Soil Scientist

COMMENTS OF THE DEPARTMENT OF TRANSPORTATION

U.S. Department
of Transportation

United States
Coast Guard



Commandant
U.S. Coast Guard

2100 Second St. S.W.
Washington, DC 20593-0001
Staff Symbol: G-MEP-3
Phone: (202) 267-0500

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OCT 31 1994

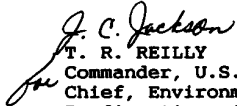
Mr. Donald A. Banashek
Director
Washington Level Review Center
ATTN: CEWRC-WLR-E (SA)
7701 Telegraph Road
Alexandria, Virginia 22060-5576

Dear Mr. Banashek:

This is in response to your letter of October 5, 1994, transmitting the proposed report of the Chief of Engineers, the district engineer's report, and the final environment impact statement on Guanajibo River, Puerto Rico. We have reviewed the reports and have no comments to offer.

Thank you for the opportunity to review this project.

Sincerely,


T. R. REILLY
Commander, U.S. Coast Guard
Chief, Environmental Coord. Br.
By direction of the Commandant

COMMENTS OF THE ENVIRONMENTAL PROTECTION AGENCY



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION II

JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, NEW YORK 10278-0012

JAN 06 1995

Donald A. Banashek, Chief
Policy Review Branch
U.S. Army Corps of Engineers
Attn: CECW-AR (SA)
7701 Telegraph Road
Alexandria, Virginia 22315-3861

Dear Mr. Banashek:

The Environmental Protection Agency (EPA) has reviewed the final environmental impact statement (EIS) for the Rio Guanajibo Flood Protection Project, in Mayaguez and San German, Puerto Rico. This review was conducted in accordance with Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609, PL 91-604 12(a), 84 Stat. 1709), and the National Environmental Policy Act.

The proposed project would provide flood protection to urban areas along Rio Guanajibo. The recommended plan includes a levee and floodwall system to provide 100-year flood protection in the Mayaguez-Hormiguero area; proposed channel improvements, including bridge replacement, would provide the San German area protection against a 10-year flood. Based on our review, we offer the following comments.

The preferred plan presented in the draft EIS would have impacted 22.5 acres of mature mangrove forest and 4.6 acres of cattail wetlands. The preferred plan has been modified in the final EIS. Specifically, the improvements at Cano Majagual, in the Rio Guanajibo basin, have been eliminated, reducing direct mangrove impacts by 0.91 acres and eliminating all impacts to the cattail wetlands. Furthermore, the levee around the Guanajibo Homes development has been shifted to protect a radio station, resulting in the hydrological isolation of 6 acres of mangroves. Therefore, the total wetlands losses associated with the revised plan are the direct filling of 21.6 acres of mangrove forests and the potential elimination, through hydrological isolation, of 6 additional acres of mangroves.

In our September 12, 1994 comment letter on the draft EIS, we requested additional information on measures to avoid or minimize the project's wetlands impacts. Since the draft EIS, the improvements at Cano Majagual have been eliminated, thereby reducing mangrove impacts and all impacts to the cattail wetlands. Further, the final EIS states that measures to maintain the isolated mangroves through flushing will be evaluated during the

project's design phase. We concur with these measures; however, we believe that there are additional measures that should be explored. In particular, the option of moving the levee closer to the Guanajibo Homes development would reduce the area of isolated mangroves. Similarly, because a flood wall would have a smaller footprint than a levee, construction of the floodwall in this area would further reduce the direct wetlands impacts. With the above in mind, we request that additional measures to minimize wetlands impacts be explored prior to issuing the record of decision (ROD).

The proposed mitigation plan would create 27.6 acres of new mangrove forest adjacent to an existing mangrove area, through an active planting and seeding plan to increase the probability of success. We concur with this approach; however, we recommend that the mitigation plan include a monitoring program to appraise the success of recolonization, and a contingency plan if recolonization fails. We request an opportunity to review the wetlands mitigation plan before it is finalized.

In our comments on the draft EIS, we requested that a more complete discussion of the feasibility of partial or complete evacuation, and other non-structural alternatives, be included in the final EIS. The document states that real estate, relocation, and infrastructure costs associated with a non-structural alternative would be in excess of \$250 million. As such, a non-structural alternative would be 10 times the cost of the preferred alternative; we concur that it would not be a cost-effective alternative for this project.

In our draft EIS comments, we requested that the sediment excavated as a result of this project be evaluated for the presence of hazardous contaminants prior to disposal. The final EIS presents a review of the surrounding area, and concludes that there is a low probability of encountering hazardous contaminants in the excavated sediment. Nevertheless, we are pleased to note that random sampling of the excavated sediment will be conducted to determine whether it contains any hazardous substances. We would like to review the sampling plan when it becomes available. In a related matter, we requested that the final EIS identify a health and safety plan for the workers and public. Based on our discussion with Barbara Cintron of your staff, we understand that a health and safety plan for dealing with possible hazardous contaminants will be developed as part of the detailed design.

We raised concerns about turbidity impacts to the river during construction. The final EIS states that turbidity screens and controls will be specified during the construction phase and sediment control plans will be generated as necessary. We concur with this approach.

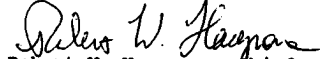
Additionally, we requested that the final EIS provide a comprehensive evaluation of secondary impacts, including appropriate mitigation measures. The final EIS states that no induced development will occur given the nature of the project. We concur with this conclusion.

In responding to our request for an analysis of the proposed project's impacts to agricultural lands and a U.S. Department of Agriculture's Farmland Conversion Impact Rating, the final EIS identifies the project's agricultural impacts and includes the Prime Farmland Rating completed by the Soil Conservation Service. This addresses our request.

In summary, based on our review of the final EIS, we do not object to the implementation of the preferred alternative. However, we have a minor concern regarding additional wetlands minimization efforts that should be addressed prior to the issuance of the project's ROD. Also, we would like the opportunity to review the wetlands mitigation plan and the excavated sediment sampling plan before they are finalized.

In the interim, should you have any questions concerning our comments, please contact Ms. Evelyn Tapani-Rosenthal of my staff at (212) 264-6689.

Sincerely yours,



Robert W. Hargrove, Chief
Environmental Impacts Branch

cc: W. Fonferek, USACE - Jacksonville District

**LETTER TO THE ENVIRONMENTAL PROTECTION
AGENCY**

22 AUG 1995

Planning Division
Eastern Planning Management Branch

Mr. Robert W. Hargrove
Chief, Environmental Impacts Branch
Environmental Protection Agency - Region II
Jacob K. Javits Federal Building
New York, New York 10278-0012

Dear Mr. Hargrove:

This is in response to your letter dated January 6, 1995, on the final environmental impact statement (FEIS) for the proposed Rio Guanajibo flood protection project.

We appreciate your comments and the effort your staff has expended reviewing this document. We offer the following responses to questions or requests you have made with regard to our report:

a. Reference paragraph 4. Request that additional alternatives to void impact to mangroves be explored; i.e., moving the floodwall closer to Guanajibo Homes.

Response: The proposed floodwall from Puerto Rico Highway 102 to the radio station was selected because of real estate limitations. It is not possible to build a levee between Cano Corazones and Guanajibo Homes/Radio Station. The reason for not continuing with this proposed floodwall around Guanajibo Homes was cost. Building a floodwall in the marsh area would require additional foundation preparation which would result in a higher cost and similar environmental impacts when compared to building a levee.

b. Reference paragraph 5. Recommend that the mitigation plan include a monitoring program and contingency program.

Response: Reference exhibit V, FEIS, Selected Mitigation Plan. The mitigation plan does include a monitoring program with contingencies for correcting problems with the wetland creation. The final design is to be coordinated with the U.S. Fish and Wildlife Service during the preconstruction engineering and design phase and will be provided to you at that time.


c. Reference paragraph 11. Request for a review of the mitigation design plan and excavated sediment sampling plan.

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Response: Reference the response to paragraph 5. The sediment sampling plan will be provided to you prior to finalization.

I hope these responses alleviate your concerns at this stage of the planning process. The U.S. Army Corps of Engineers looks forward to continuing the cooperation and coordination between our offices as this project proceeds through the design and development phases.

Sincerely,


G. Edward Dickey
Chief, Planning Division
Directorate of Civil Works

per

GUANAJIBO RIVER, PUERTO RICO

REPORT OF THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY



**DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000**

REPLY TO
ATTENTION OF:

CECW-PE (10-1-78a)

27 February 1996

SUBJECT: Guanajibo River, Puerto Rico

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report which addresses the provision of flood damage reduction measures for the Guanajibo River area of Puerto Rico. It is accompanied by the report of the district and division engineers. These reports are being submitted as final response to Section 204 of the 1970 Flood Control Act (Public Law 91-611), which authorized the Secretary of the Army; acting through the Chief of Engineers, to cooperate with the Commonwealth of Puerto Rico in development, utilization and conservation of water and related land resources and to submit to Congress reports and recommendations with respect to the Department of the Army in carrying out such plans, which address the needs of the Commonwealth for protection against floods, wise use of floodplains, improvements for navigation facilities, regional water supply and waste management and control of water quality, enhancement and conservation of fish and wildlife, beach erosion control, and other measures for environmental enhancement. These reports are also in final response to a March 26, 1982, resolution by the Committee on Environment and Public Works of the United States Senate, and to a September 23, 1982, resolution by the Committee on Public Works and Transportation of the U.S. House of Representatives. In the resolutions the committees requested review of the report on Mayaguez Harbor, Puerto Rico, published as House Document 215, 72nd Congress, 1st Session, and other pertinent reports with a view to determining whether any modifications are necessary at this time in the interest of flood control, water supply, navigation and allied purposes on the Guanajibo River, Puerto Rico. Preconstruction engineering and design activities for the Guanajibo River project will be continued under the authority of these resolutions.

2. The reporting officers recommend a flood damage reduction plan which consists of a new levee project for the Mayaguez-Hormigueros area and a river channel modification project at the San German area. The recommended plan of improvement for the Mayaguez-Hormigueros area consists of 3.8 miles of levee and floodwall system along developed areas in the floodplain. As a component of the Mayaguez-Hormigueros element, the levees and floodwall at Guanajibo Homes area and the San Jose area would have a total length of about 2.0 miles, an average height of about 15.4 feet, a top elevation of 18.4 feet normal gage vertical data (NGVD), and a 0.48 percent chance of being overtopped in any given year. The levees at Valle Hermoso and Buenaventura areas, also a component of the Mayaguez-Hormigueros element, would have a length of 1.9 miles, an average height of about 14.1 feet, and a top elevation which varies; at

levee station 33+00, would have a top elevation of 33.5 feet NGVD and would have a 0.80 percent chance of being overtopped in any given year. Ditches would be provided to convey runoff collected behind the levees to culverts that would pass the flow through the levee.

3. The recommended plan of improvement for the San German area consists of about 0.9 mile of channel improvement and replacement of the Puerto Rico Highway 119 bridge. The recommended 0.9 mile of channel widening at San German area would have a bottom width of 213 feet and would be gabion lined. The Highway 119 bridge would be replaced to accommodate the larger channel and flow requirements.

4. No environmental mitigation is required for the recommended San German plan. Impacts to mangrove habitat in the Mayaguez-Hormigueros area will need to be mitigated. For mitigation of these habitat impacts, the recommended plan includes acquisition of 27.6 acres of land located between mangroves on the Cano Corazones Creek and the adjacent mangrove wetland east of the Guanajibo Homes development. The area would be graded down to the elevation of the mangroves on either side of the property and mangroves would be planted in the area.

5. The recommended plan of improvement is the national economic development (NED) plan. Based on October 1995 price level, a 50-year economic project life, and an interest rate of 7 5/8 percent, the total project has a first cost of \$27.06 million, average annual benefits of \$5.79 million, average annual cost of \$2.34 million (including interest during construction), and a benefit-cost ratio (BCR) of 2.5. Based upon existing cost sharing policy, the Federal share of the total project estimated first cost is \$19.54 million, and the non-Federal share of the total project estimated first cost is \$7.52 million. Preliminary studies of other water-related purposes in the study area were terminated because of limited economic potential for Federal participation in development of water resources projects other than for flood damage reduction.

6. Washington level review indicates that the proposed plan conforms to applicable Federal laws and regulatory requirements, is a complete and functionally adequate project, and is in compliance with other relevant Federal and Corps regulations. The report has been coordinated with appropriate Federal, Commonwealth, local, and public interests; and there are not at this time any objections to the proposed plan.

7. The Administration has initiated the development of a new cost sharing policy for flood damage reduction projects. I recommend that improvements for flood damage reduction in the Rio Guanajibo Basin be authorized subject to cost sharing that is consistent with Administration policy. This recommendation is also subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including the following requirements:

- a. Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;
- b. Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project;
- c. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, at no cost to the Government, in accordance with applicable Federal and State laws and any specific directions prescribed by the Government;
- d. Grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project;
- e. Hold and save the Government free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors;
- f. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs;
- g. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government;

- h. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project;
- i. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA;
- j. Participate in and comply with applicable Federal floodplain management and flood insurance programs in accordance with section 402 of Public Law 99-662;
- k. Prevent future encroachments on project lands, easements, and rights-of-way which might interfere with the proper functioning of the project;
- l. Not less than once each year, inform affected interests of the limitations of the protection afforded by the project;
- m. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the floodplain, and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project;
- n. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;
- o. Comply with all applicable Federal and Commonwealth laws and regulations, including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army";

8. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the Puerto Rico Department of Natural and Environmental Resources; interested Federal agencies; and other parties will be advised of any modifications and will be afforded an opportunity to comment further.



ARTHUR E. WILLIAMS
Lieutenant General, USA
Chief of Engineers

REPORT OF THE DISTRICT ENGINEER

RIO GUANAJIBO FEASIBILITY REPORT - 12320

SYLLABUS

The Río Guanajibo Feasibility Study was conducted under the authority of a resolution by the Committee on Environment and Public Works of the United States Senate dated March 26, 1982, and by a resolution of the Committee on Public Works and Transportation of the United States House of Representatives dated September 23, 1982. A detailed study for the Río Guanajibo was initiated in March of 1985. The study focused on the formulation and evaluation of flood control plans to solve the serious flooding problems resulting from the overflow of Río Guanajibo in the vicinity of the metropolitan area of Mayagüez in the coastal flood plain and the town of San Germán twelve kilometers upstream.

The Río Guanajibo basin is located in the southwestern part of Puerto Rico, about 160 kilometers from the San Juan Metropolitan Area. The basin has 345 square kilometers of flat to mountainous terrain. Heavy rainfall combined with the very steep slopes of the upper basin can produce high discharges in a relatively short period of time. Flooding in the study area affects over 2,700 families and numerous public buildings and facilities. Total expected annual equivalent damages associated with floods in the study area are estimated at \$6.6 million.

The recommended plan of improvement for the Río Guanajibo basin consists of 6.26 kilometers of floodwalls and levees system in the vicinity of the residential developments of Guanajibo Homes, San José Estates, Buenaventura, and Valle Hermoso all located in the Mayagüez-Hormigueros area. The improvements in the Guanajibo Homes/San José developments will protect it from the 0.48 percent chance (or 208 years) flood event while those Valle Hermoso/Buenaventura will protect the area from the 0.8 percent chance (or 125 years) flood event. The recommended plan also includes 1.47 kilometers of channel improvements on Río Guanajibo in the San Germán area to protect it from the 10-year flood. The plan integrates environmental elements to minimize potential adverse impacts. Some 2,500 families currently living in the flood plain would be protected from the overflow of Río Guanajibo.

Total first cost of the recommended plan is \$26,140,500. Net National Economic Benefits are in the order of \$3,990,900 and the benefit to cost ratio is 2.8/1.0. The recommended plan is the National Economic Development Plan. The Federal contribution for the implementation of the plan would be \$18,866,900, while the non-Federal share would be \$7,273,600 which represents 28 percent of the total project cost.

RIO GUANAJIBO FEASIBILITY REPORT

MAIN REPORT

I. AUTHORITY

The Río Guanajibo Study was initiated under the authority of Section 204 of the 1970 Flood Control Act (PL 91-611) which reads as follows:

Sec. 204. (a) The Secretary of the Army, acting through the Chief of Engineers, is authorized to cooperate with the Commonwealth of Puerto Rico, political subdivisions thereof, and appropriate agencies and instrumentalities thereof, in the preparation of plans for the development, utilization, and conservation of water and related land resources of drainage basins and coastal areas in the Commonwealth of Puerto Rico, and to submit to Congress reports and recommendations with respect to appropriate participation by the Department of the Army in carrying out such plans. Such plans that may be recommended to the Congress shall be harmonious components of overall development plans being formulated by the Commonwealth and shall be fully coordinated with all interested Federal agencies.

(b) The Secretary of the Army, acting through the Chief of Engineers, shall consider plans to meet the needs of the Commonwealth for protection against floods, wise use of flood plain lands, improvements of navigation facilities, regional water supply and waste management and control of water quality, enhancement and conservation of fish and wildlife, beach erosion control, and other measures for environmental enhancement.

Funding for Section 204 was discontinued in fiscal year 1981 and the study was not re-initiated until fiscal year 1985. It was conducted under a U. S. Senate resolution of March 26, 1982, and a U. S. House of Representatives resolution of September 23, 1982. The respective resolutions read as follows:

RESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors is hereby requested to review the report of the Chief of Engineers on Mayagüez Harbor, Puerto Rico, published as House Document Number 215, 72nd Congress, 1st Session, and other pertinent reports with a view to determining whether any modifications are necessary at this time in the interest of flood control, water supply, navigation and allied purposes on the Guanajibo River, Puerto Rico. Such efforts shall be harmonious with, and a continuation of, related studies conducted under Section 204 of the 1970 Flood Control Act, Puerto Rico Cooperative Study.

RESOLVED BY THE COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION OF THE HOUSE OF REPRESENTATIVES, UNITED STATES, that the Board of Engineers for Rivers and Harbors is hereby requested to review the report of the Chief of Engineers on Mayagüez Harbor, Puerto Rico, published as House Document Number 215, 72nd Congress, 1st Session, and other pertinent reports, with a view to determining whether any modifications are necessary at this time in the interest of flood control, water supply, navigation and allied purposes on the Guanajibo River, Puerto Rico. Such efforts shall be harmonious with, and a continuation of, related studies conducted under Section 204 of the 1970 Flood Control Act, Puerto Rico Cooperative Study.

The purpose of the feasibility study was to evaluate flooding problems along Río Guanajibo and to determine the economic, engineering, and environmental feasibility of implementing urban flood damages reduction measures.

A first draft of the Río Guanajibo Feasibility Report was completed in March 1991. Review Conference was held in San Juan, Puerto Rico, on May 15, 1991. Concerns on plan formulation and geotechnical investigations were main causes for the substantial amount of study revisions required to comply with PGM comments. Main issues presented in the PGM are:

- Material suitability for levee construction. Additional geotechnical information was required to address questions on proposed borrow and disposal site.
- Concerns about operational and safety considerations on proposed levee system for the 25-year flood in San Germán.
- Significant amount of undeveloped land being protected by proposed levee system in the Mayagüez-Hormigueros area.
- Environmental concerns related to wetlands being cut-off from the flood plain by proposed levee system in the Mayagüez-Hormigueros area and proposed mitigation plan.

This final report addresses these issues and presents a recommended plan to solve the area's serious flooding problems maximizing net benefits.

II. SCOPE

A. Study Area

The Río Guanajibo watershed (Figure 1) is the largest in the southwest of Puerto Rico and includes portions of the municipalities of Mayagüez, Hormigueros, Cabo Rojo, San Germán, Sabana Grande, and Maricao. Study efforts were concentrated in analyzing flooding problems in the developed areas of Mayagüez, Hormigueros, and San Germán. Flooding in the town of Sabana Grande was addressed through a Section 205 flood control project completed in June 1989. The town of Maricao is within the upper basin, out of the flood plain. The town of Cabo Rojo was originally considered in the reconnaissance study. However, the local

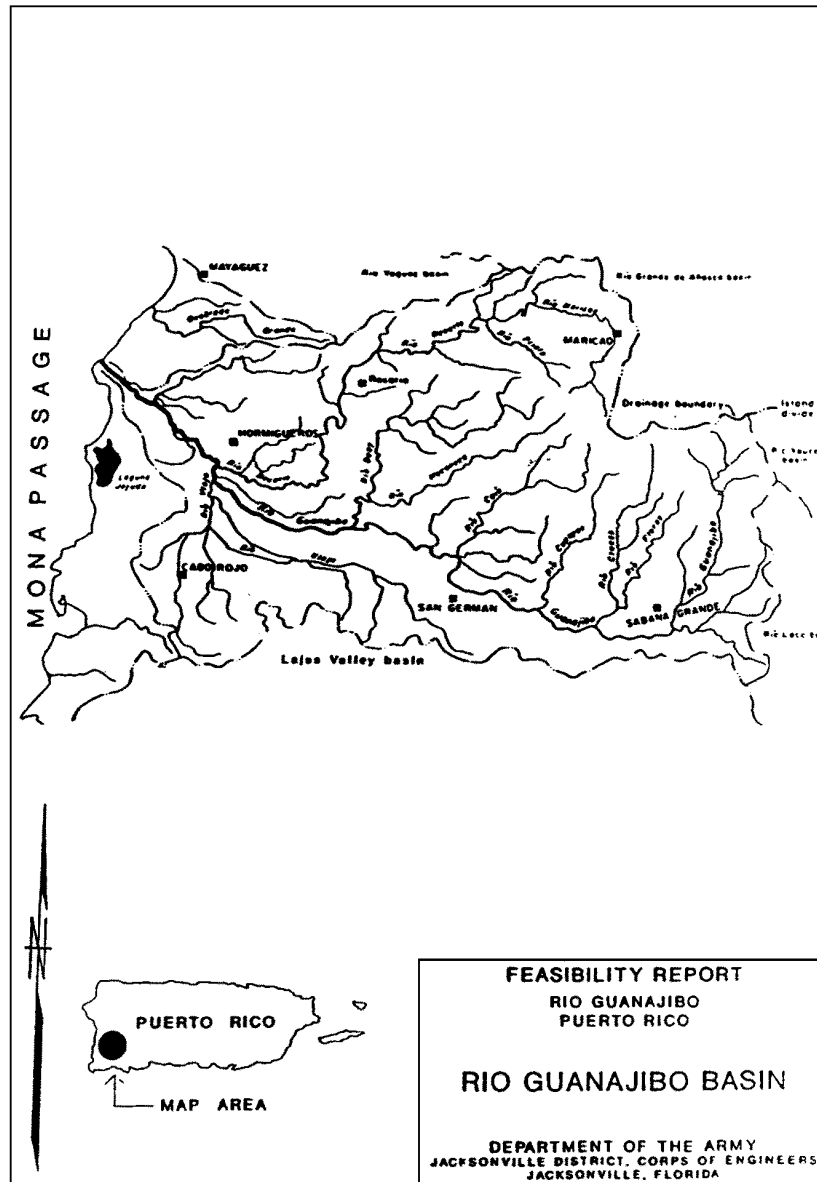


FIGURE 1

sponsor, the Department of Natural and Environmental Resources (DNER), during the 1980-1985 time frame completed several flood control measures to substantially reduce flood damages in the vicinity of the town. Therefore, the town of Cabo Rojo was dropped from the scope of work for the feasibility study.

The detailed study area consists of the Río Guanajibo coastal flood plain, south of the city of Mayagüez extending upstream for about 7 kilometers to a developed area south of the town of Hormigueros, and the floodable area in the town of San Germán, which is 20 kilometers upstream from the river outlet. For the purpose of analysis and discussion, the study area is divided into two separate detailed study areas. These are: the Mayagüez-Hormigueros area and the San Germán area (Plate 1).

B. Study Participants and Coordination

Coordination of this report was accomplished through numerous formal and informal meetings with various Commonwealth and Federal agencies, municipality officials, various interested groups, and the residents of the flood plain. Table 1 shows the participating government agencies. The study was thoroughly coordinated with the DNER, which is the local sponsor.

The meetings held with representatives from the various government agencies were aimed at the collection of data necessary for the study and at the assessment and evaluation of the various flood control alternatives considered. A major objective of the coordination effort is to involve the local governments and citizen representatives as equal partners in the study process.

C. Organization of the Report

The results of the study are presented in a Main Report, an Environmental Impact Statement, and six appendices. The Main Report includes a description of the basin, an analysis of the study area's flooding problems, plan formulation and evaluation process, and the conclusions and recommendations of the study. The Final Environmental Impact Statement includes a description and analysis of the study area's environmental resources as well as the evaluation of the potential effects the alternative plans of action considered would have on these resources and the rest of the area's human environment. Throughout the document, reference is continuously made to inputs and comments from other federal resources agencies, particularly the U. S. Fish and Wildlife Service (FWS) and the Environmental Protection Agency (EPA). The appendices provide the supporting data and detailed investigations conducted as part of the study. These include: Appendix A, Hydrology and Hydraulics; Appendix B, Geotechnical Studies; Appendix C, Design and Cost Estimates; Appendix D, Coordination; Appendix E, Economic Analysis; and Appendix F, Real Estate Analysis.

TABLE 1
RIO GUANAJIBO FEASIBILITY STUDY

PARTICIPATING GOVERNMENT AGENCIES

FEDERAL	COMMONWEALTH	LOCAL
Department of the Interior U.S. Geological Survey U.S. Fish and Wildlife Service National Park Service	Department of Natural and Environmental Resources (Sponsor) Office of the Governor Planning Board Environmental Quality Board	Municipalities of Mayagüez, Hormigueros, and San Germán Office of the Mayor of Mayagüez Office of the Mayor of Hormigueros Office of the Mayor of San Germán Office of Planning Department of Public Works Civil Defense
Department of Transportation Federal Highway Administration	Legislature of Puerto Rico House of Representatives Senate	
Environmental Protection Agency	Office of the Resident Commissioner	
Department of Housing and Urban Development	Puerto Rico Planning Board	
Department of Agriculture Soil and Conservation Service	Regulations and Permits Admin.	
Department of Commerce National Weather Service Office of Coastal Zone Management National Marine Fisheries Service	Civil Defense	
Federal Emergency Management Agency	Department of Transportation and Public Works Highways Authority Historic Preservation Office Department of Agriculture Office of the Budget Department of Sports and Recreation Department of Housing Department of Social Services Department of Education Police Department Aqueduct and Sewers Authority Electric Power Authority	

III. DESCRIPTION OF THE RIO GUANAJIBO BASIN

A. Physiography

1. The river basin. The Río Guanajibo basin is located in the southwestern part of Puerto Rico about 160 kilometers southwest of the San Juan Metropolitan Area and comprises the municipalities of Mayagüez, Hormigueros, Cabo Rojo, San Germán, Sabana Grande, and Maricao (Figure 1). The basin has a roughly rectangular shape measuring about 29 kilometers along its east-west axis and 13 kilometers along its north-south axis. The basin has 345 square kilometers of flat to mountainous terrain. The head waters of Río Guanajibo are about 10 kilometers north of Sabana Grande at 800 meters (NGVD) in the Cordillera Central mountain range and flows in a westerly direction for about 35 kilometers to its outlet at Mayagüez Bay and the Caribbean Sea. The basin falls within both the humid mountain and the coastal plain physiographic regions. It is bounded on the north by the Río Yagüez and the Río Grande de Añasco, on the east by the Río Yauco, and on the south by the Lajas Valley basin.

2. Main stream and tributaries. The major tributaries have their source in the mountains and drain the area north of the Río Guanajibo basin. These tributaries are: Río Hondo, Río Rosario, Río Duey, Río Caín, Río Cupeyes, Río Cruces, and Río Coco. The drainage area of the south portion of the basin is relatively small and tributaries are few. Río Viejo is the largest of these streams. In the lower basin there is an array of small streams and canals that provide drainage for the city of Mayagüez towards the Río Guanajibo valley. These are: Caño Merle, Quebrada Sábalos, and Caño Majagual. Caño Corazones, an old outlet of the main river, is another system that drains the lower flood plain directly into the bay.

3. Waterworks. There are no major waterworks in the basin. The Puerto Rico Aqueducts and Sewers Authority (PRASA) evaluated a proposed water supply reservoir for the Río Rosario basin in a 1983 study and it was considered not cost effective. Additional information is provided in Chapter IV, B. Water Supply.

4. Climate. The island of Puerto Rico possesses a tropical marine climate. Warm temperatures with little variations, steady ocean breezes, and abundant rainfall result from a constant high level of solar radiation, the presence of trade winds from the northeast, and the mountainous topography of the island. Mean annual temperature ranges from 23.5 degrees Centigrade in the upper basin to 25.2 degrees Centigrade in the coastal area. There is a considerable variation in the parameter of rainfall within the basin. In the town of Maricao, which is located in the north east portion of the upper basin, the mean annual precipitation is 251.2 centimeters, while for the coastal area in the west portion of the basin the mean annual precipitation is 153.6 centimeters.

5. Soils. In accordance with the U. S. Soil Conservation Service, the soils at the upper portion of the basin consist of slightly leached, loamy and clayey, sticky and plastic soils underlain by hard or weathered rock at a depth of less than 30 inches. Most of the flood plain is covered by the Coloso-Toa association. These are nearly level porous soils that are loamy throughout. The Coloso silty clay loam is a

poorly drained soil that is fertile and has high available water capacity. The Toa series consists of deep, moderately well-drained soils that are slightly acid and moderately permeable. These soils are formed in stratified fine textured alluvial sediments. The mangrove forest along the coastal valley is classified as Tidal Swamp. These soils consist of light colored, saline, sandy or clayey material, and some organic material from decaying mangrove trees. The underlying material consist of coral, shells, and marl.

B. Socioeconomic Profile

The study areas under consideration, the Mayagüez-Hormigueros area and the Municipality of San Germán, are located in the western part of Puerto Rico about 98 miles from the San Juan Metropolitan Area.

The city of Mayagüez is the major center of economic activity in the entire western region, which includes fifteen municipalities. It provides employment opportunities and essential services such as education, health, government, and retail jobs for the region. It is the seat of the state's Engineering School of the University of Puerto Rico, the third largest ports facility on the island, and has the largest regional shopping center of the area. The Tropical Agricultural research station of the U. S. Department of Agriculture, now used as a touristic attraction, is also located here. Fifty miles west of Mayagüez is Mona Island, former home for Taino Indians and today a nature refuge.

1. Population. As shown on Table 2 and Figure 2, the 1990 population of the area was 150,545 which represents a 5 percent growth from the 1980 population. About 67 percent of the total study area population resides in the Municipality of Mayagüez and of this 86 percent is urban.

2. Economic base. The economic base of the municipality revolves around a major and diversified manufacturing sector, government, and services activities. The Puerto Rico Department of Labor estimated the civilian labor force at 86,100 persons in 1993 for the Mayagüez Labor Market Area, which includes the municipalities of Hormigueros, San Germán, Añasco, Cabo Rojo, and Mayagüez itself. This figure shows an increase of 14,800 from 1985 and 4,500 since 1990. As a result, the area showed a reduction in the unemployment rate from 20.8 percent (1985) to 14.7 percent in 1990 (see Table 3), but a slight move up to 15.4 percent at the end of December 1993. The predominant employment generating sectors for the area are government, manufacturing, and a growing services, commerce, and insurance-finance sectors.

Total employment in the study area is expected to increase during the next few years as a result of the starting operations of a manufacturing plant, two major retail stores, and the construction of eight new office buildings. Some of the new projects include: the Federal Post Office building, sports complex and water tank in Hormigueros, basketball courts, swimming pools, and recreational areas in San Germán.

Table 4 shows the distribution of the employed people by principal occupational category for each of the study areas for 1990. About 28 percent are within the technical sales and administrative

TABLE 2
RIO GUANAJIBO FEASIBILITY REPORT

POPULATION BY MUNICIPALITIES
IN THE DETAILED STUDY AREA

MUNICIPALITY	1980	1990
MAYAGUEZ	96,193	100,371
HORMIGUEROS	14,030	15,212
SAN GERMAN	32,922	34,962
TOTAL	143,145	150,545

Source: U.S. Department of Commerce, Bureau of Census
1990 Population for Puerto Rico

POPULATION BY MUNICIPALITIES IN RIO GUANAJIBO STUDY AREA

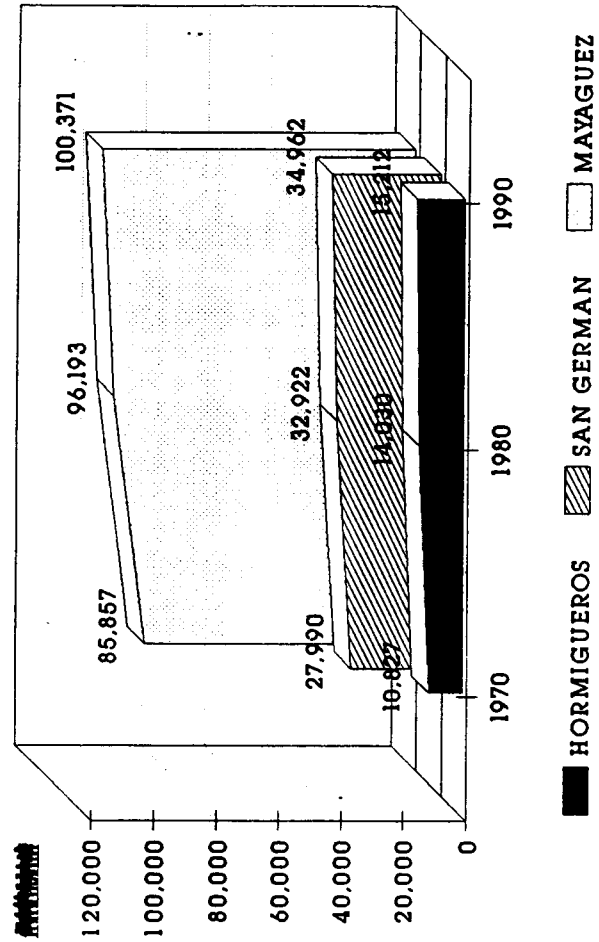


Figure 2

TABLE 3
RIO GUANAJIBO FEASIBILITY REPORT

CIVILIAN LABOR FORCE CHARACTERISTICS AND EMPLOYMENT DATA
FOR MAYAGUEZ LABOR MARKET AREA*

DESCRIPTION	1985	1990	1993
Civilian Labor Force	71,300	81,600	86,100
Unemployment Total	14,800	12,000	13,300
Unemployment Rate (%)	20.8%	14.8%	15.4%
Employment Total	56,500	69,600	72,800
Manufacturing	19,300	20,400	16,500
Agriculture	8,800	8,100	8,000
Wholesale and Retail	5,900	8,500	10,700
Government	15,000	21,100	20,000
All Other (services, finance, insurance, real estate, transportation)	7,500	11,500	17,000

Source: Department of Labor and Human Resources
Household Survey, September 1985, June 1990 and December 1993

*Includes the municipalities of Mayagüez, San Germán, Añasco, Cabo Rojo, and Hormigueros.

TABLE 4
RIO GUANAJIBO FEASIBILITY REPORT

CHARACTERISTICS OF THE EMPLOYED PERSONS BY OCCUPATIONAL CATEGORY
FOR THE MAYAGUEZ-HORMIGUEROS AND SAN GERMAN AREAS
1990

OCCUPATIONAL CATEGORY	MAYAGUEZ- HORMIGUEROS AREA	SAN GERMAN AREA	TOTAL
ALL CATEGORIES	32,586	9,518	42,104
Professional, Technical, and Managerial	7,530	1,879	9,409
Technical, Sales, and Administrative Support	9,490	2,504	11,994
Services Occupations	4,082	1,388	5,470
Agricultural, Fishery, Forestry, and Related	474	423	897
Processing, Precision Production	3,528	1,032	4,560
Operators, Fabricators, Laborers, and Unclassified	7,482	2,292	9,774

Source: U.S. Department of Commerce, Bureau of Census, 1990

support category, while 22 percent are the managerial and professional occupations. Some 23 percent are classified as operators and laborers. Figure 3 shows this distribution for the Mayagüez statistical area.

Table 5 shows the distribution of families by income groups for 1990 in the Mayagüez-Hormigueros area. There were 2,850 families with an annual income less than \$1,000, while 5,048 have annual incomes of \$25,000 or more. For the San Germán area, the corresponding figures are 470 families and 1,176 families. The median household income for both areas is estimated at about \$9,000.

C. Land Use

The vegetation cover of the uplands is generally good. The Commonwealth Government and the U. S. Forest Service manage 41.4 square kilometers of the Maricao Forest. This and other forest areas privately managed cover approximately 34 percent of the basin area (Figure 4). Agriculture with 57 percent (i. e. pasture, row crops, coffee, sugar cane, and some other miscellaneous crops) is the most extensive land use within the Río Guanajibo basin. Urban development is limited to 7 percent. Land use in the coastal flood plain is limited by the Caño Corazones mangrove forest and the Merle Marsh. The wetland area covers approximately 2.3 square kilometers of the coastal valley (Table 6).

D. Natural Resources

1. Water resources. According to the U. S. Geological Survey (USGS), the mean annual flow of Río Guanajibo at PR Highway 100 is about 6 cms. Seasonal fluctuations can reduce the flow as low as 0.2 cms. The quality of the water is suitable for most uses. The mean annual suspended-sediment load is about 120 metric tons per year. Ground water occurs in sand and gravel deposits and in fractured and porous limestone. Specific capacities of wells in the valley range from 0.5 to 8 liters per second per meter. Ground water is of good chemical quality. No evidence of salt water intrusion has been detected.

2. Environmental resources. Extensive wetland areas cover the lower coastal flood plain of Río Guanajibo. Downstream from PR Highway 100, five wetland areas were identified. These are: Guanajibo Homes, Caño Corazones, Caño Majagual, Merle Marsh, and the Río Guanajibo flood plain (Figure 4).

The Guanajibo Homes area is classified as estuarine, intertidal, forested, broad-leaved evergreen wetland (E2F03). The area includes a mature wetland forest dominated by black mangrove in the north. On the other hand, the southern portion is a more diverse wetland forest dominated by *Pterocarpus*, red and white mangroves, royal palms, and leather ferns. Both portions are irregularly flooded by tides and receive freshwater from precipitation and overbank flooding from the Río Guanajibo.

The Caño Corazones and Caño Majagual have the same E2F03 wetland classification with red, black, and white mangrove present. Much of the area is regularly flooded by tides. There is an inflow of fresh water to the area from the Merle Marsh to the northeast, from precipitation, and overbank flooding from the river during extraordinary events.

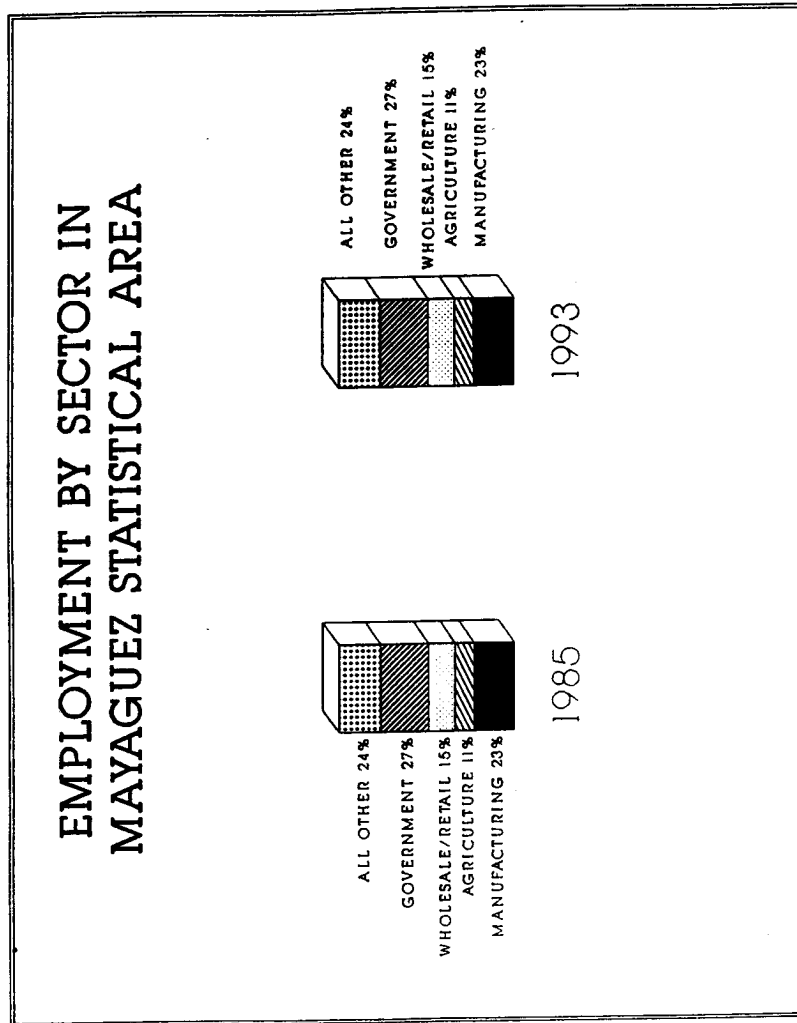


Figure 3

TABLE 5
RIO GUANAJIBO FEASIBILITY REPORT

DISTRIBUTION OF HOUSEHOLDS BY INCOME GROUP IN 1990
FOR THE MUNICIPALITIES OF MAYAGUEZ-HORMIGUEROS
AND THE SAN GERMAN AREA

INCOME RANGE	MAYAGUEZ-HORMIGUEROS AREA		SAN GERMAN AREA	
	1990	PERCENT	1990	PERCENT
Less than \$1,000	2,850	8.0	470	4.4
\$1,001 to \$2,499	3,031	8.0	917	8.5
\$2,500 to \$4,999	6,134	17.0	2,002	18.5
\$5,000 to \$7,499	5,043	14.0	1,506	13.9
\$7,500 to \$9,999	3,758	10.0	1,239	12.0
\$10,000 to \$12,499	3,084	8.0	1,039	9.6
\$12,500 to \$14,999	2,415	7.0	716	6.6
\$15,000 to \$24,999	5,340	14.0	1,711	16.0
\$25,000 or More	5,048	14.0	1,176	10.5
Total	36,703	100	10,776	100

Source: U.S. Department of Commerce, Bureau of Census, 1990.

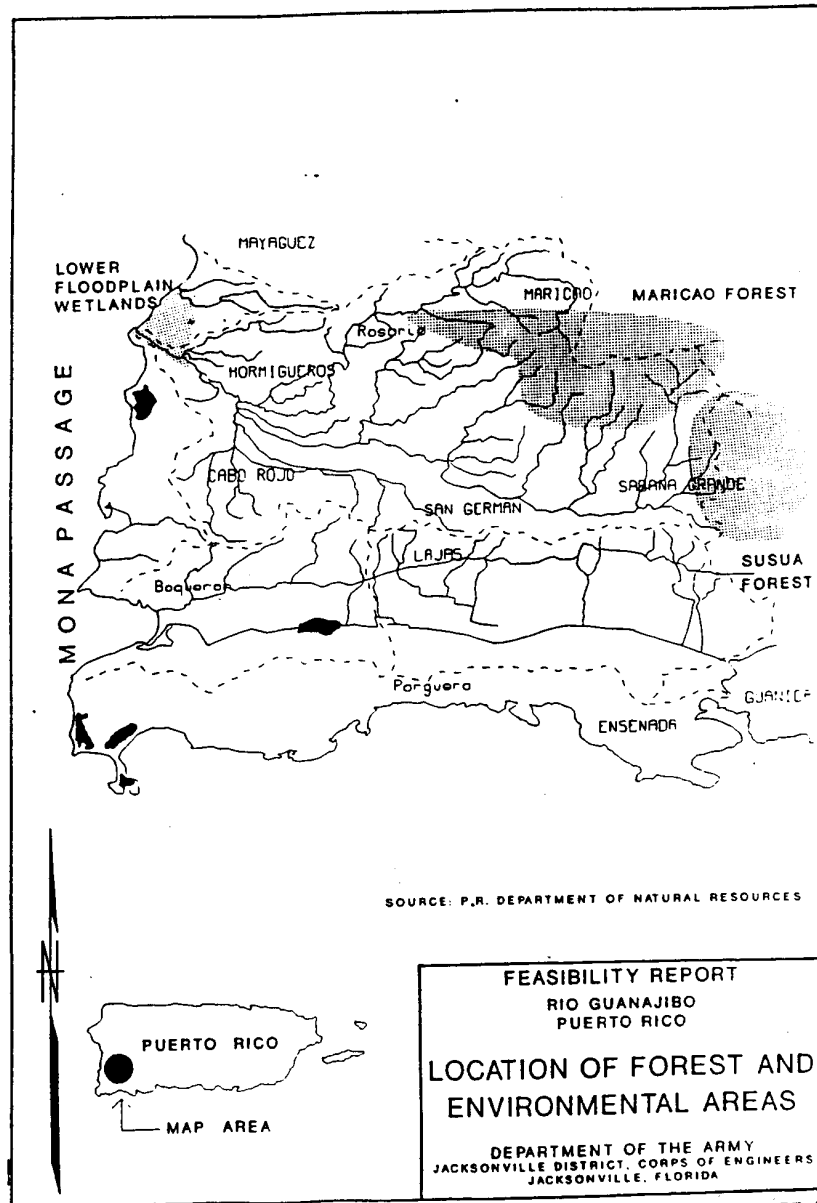


FIGURE 4

TABLE 6
RIO GUANAJIBO FEASIBILITY REPORT

PREDOMINANT LAND USE

USE	SQUARE KM.	PERCENT
Agriculture	195.9	56.8%
Forestry	117.3	34.0%
Rural	11.7	3.4%
Urban	8.6	2.5%
Other	11.4	3.3%
Public	2.2	0.6%
Wetlands	2.0	0.6%
Water Resources	1.4	0.4%
Non-Productive	1.1	0.3%
Emb. Waters	1.0	0.3%
Industrial	0.9	0.3%
Commercial	0.9	0.2%
Recreation	0.8	0.2%
Transportation	0.6	0.2%
Extraction Areas	0.6	0.2%
Communication	0.1	0.0%
Total	356	

The Merle Marsh is a palustrine, emergent, persistent wetland. The area is a freshwater marsh dominated by cattail and giant sedge along with various other emergent species.

The Río Guanajibo flood plain is a palustrine, emergent, persistent, farmed wetland. The area consists primarily of sugar cane fields and pasture which is typical of much of the Río Guanajibo flood plain.

Adjacent to the mangrove forest, vegetation is typical of sandy shores. Grasses are abundant and the most dominant tree is the Australian pine. Sea grapes, coconut palms, and Panama trees are also present. Excluding the wetlands and beach strand ecosystems, nearly all the remaining flood plain consists of sugar cane fields and pasture. Sugar cane fields extend nearly all the way to the river banks, with just a narrow wooded fringe on each side of the river. Nearly pure stands of bamboo are occasionally interrupted by mango, almond, coconut, and royal palm trees.

In accordance with the U. S. Fish and Wildlife Service Planning Aid, the northeastern fourth of the watershed is classified as subtropical wet forest, most of which is located within the Maricao Forest. The soils in this area provide a unique condition for a highly diversified flora, including several plant species not found elsewhere in the island. The vascular flora totals 845 species, including 123 species endemic to Puerto Rico.

Intensive sport fishing and limited commercial fishing occurs in the estuarine areas along the coast near the river outlet. Hook and line fishing is generally conducted in the area the day after heavy rains. The tarpon and the snook are the most important sport fish sought in the area. Crustaceans and molluscs abound in the mangrove forest. The highly prized land crab and different varieties of oysters are trapped around the mangroves for commercial or own consumption purposes.

3. Mineral resources. Sand and gravel deposits have been exploited on a moderate scale along the Río Guanajibo basin. Quarries in Sabana Grande, San Germán, Hormigueros, and Cabo Rojo have provided millions of metric tons of excellent river sand and gravel for the construction industry. The municipal government periodically removes an undetermined amount of sand from the large sand bar located at the mouth of the river. In accordance with DNER, there are four private companies with a total authorized gravel mining volume of 3,000 cubic meters/daily within the Río Guanajibo basin currently under operation.

E. Cultural Resources

History effectively began on the west coast of Puerto Rico on November 20, 1493, during the second voyage of Christopher Columbus. Alternative sites for the village seen by Columbus during the two days of his first trip to the island are in the Boquerón Bay area and in Machueca in the Río Grande de Añasco area, south and north of the Río Guanajibo basin. No major indian village has been identified within the Río Guanajibo basin. In accordance with the archaeological reconnaissance for the basin, the west coast indians had little time for

contact with the spaniards before they were removed from their village to serve as slaves. As a result, not much information is available of that historic period for the area.

San Germán, the largest early town in western Puerto Rico, experienced several relocations before being established in its present location during the period of 1571-1573. Settlement probably existed in Puerto Rico by 1506 on the Río Grande de Añasco, but the earliest mention of Spanish settlement in the Río Guanajibo basin is in 1543, when a group of farmsteads were reported in the Lomas de Santa Marta, the present location of San Germán.

The earliest Spanish economic activities in Puerto Rico was related to the exploitation of gold and silver. However, during the sixteenth century, this was replaced by the sugar industry. The southwestern section of the island was later to become a major agricultural area, and it is presumed to have been utilized for similar purposes during the early years of the colony. The emphasis on sugar became so intensive that by the end of the nineteenth century sugar milling experienced a major technological shift to steam power, and large agro-business complexes (Haciendas or Estancias) were established. Some haciendas even issued coinage to their workers to purchase items at their own stores. Many sites related to the nineteenth century are to be expected within the Río Guanajibo basin.

IV. PROBLEMS, NEEDS, AND OPPORTUNITIES

A. Flooding

1. General. The Río Guanajibo basin is subject to relatively high intensity precipitation of short duration, which combined with the steepness of the upper slopes of the river produce a very short time of concentration. Severe flooding in the basin is generally associated with the passage of hurricanes, tropical storms, tropical depressions, tropical waves, and stationary fronts through or near the island.

The city of Mayagüez and the town of Hormigueros, located in the lower valley, and the town of San Germán, located within the mid valley, have experienced frequent serious flooding. Flooding problems in these urbanized areas are mostly related to overflows from Río Guanajibo.

Some 2,736 families in the detailed study area will be affected by the 100-year flood event. In addition, dozens of public buildings (particularly schools), roads, power, water, sewer, and communications utilities and hundreds of industrial and commercial establishments will experience considerable flooding.

2. Historical floods. Historical floods in the Río Guanajibo basin have significantly affected the urban areas of the detailed study area. Since the turn of the century there have been, according to the USGS, 12 major floods. The most severe in the modern history of the Río Guanajibo occurred on September 16, 1975, with the passage through the island of Hurricane Eloise (Figures 5 and 6). The flood had an estimated recurrence interval of 100 years. The second most severe flood in the basin was associated with the passage of Hurricane San Ciriaco on

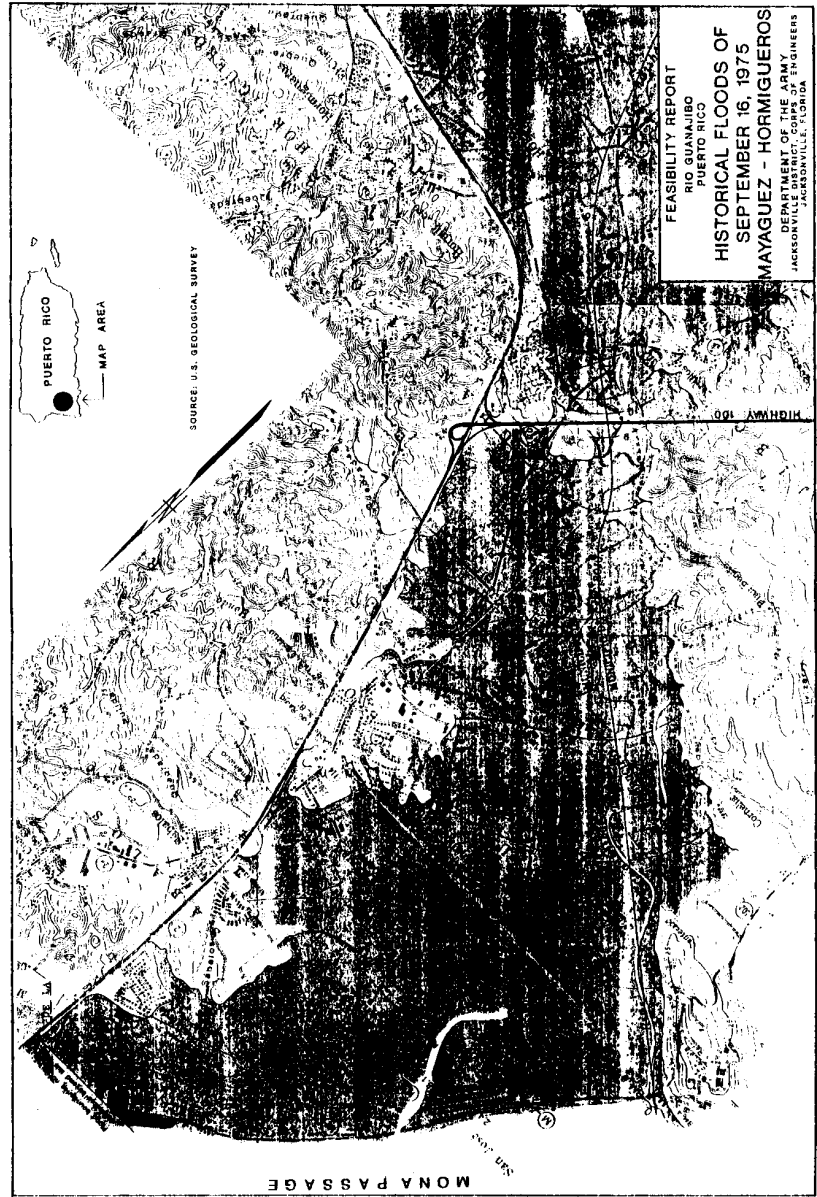
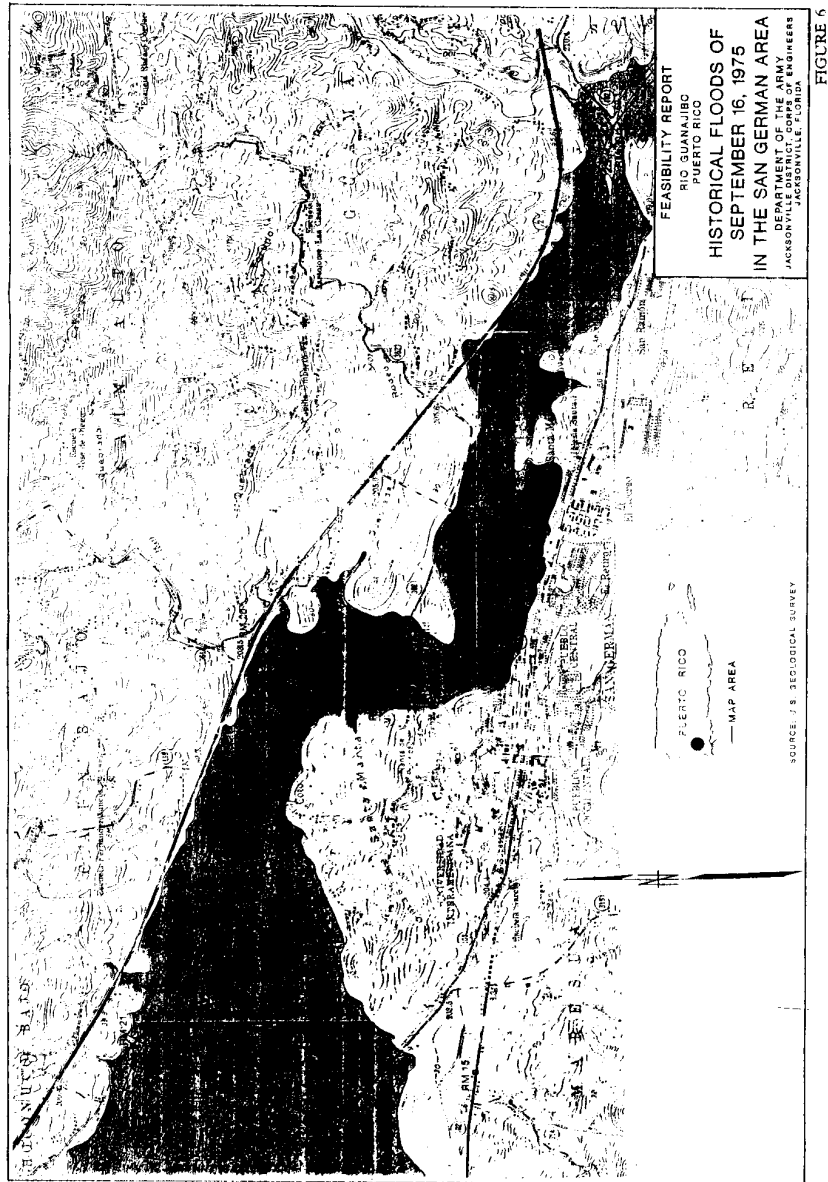


FIGURE 5



August 8, 1899. The flood had an estimated recurrence interval of 80 years, but the extent of the inundation has not been determined. Another major flood occurred on September 13, 1928, associated with Hurricane San Felipe. The 1928 flood had an estimated recurrence interval of 35 years. The August 4, 1945, flood is the fourth largest flood of records with an estimated recurrence interval of 15 years.

3. Historical damages. Heavy rainfall associated with the pass of hurricane Eloise fell over Puerto Rico for three days on September 15, 16, and 17, 1975. Damages to property and life were concentrated within the southwestern portion of the island. The most heavily damaged area was in or near Ponce, Yauco, Sabana Grande, San Germán, Hormigueros, and Mayagüez. The early warning and the relatively lighter rains on the first day gave the Civil Defense some time to mobilize for the emergency; but even so, there were 34 deaths with 29 additional people missing, over 10,000 refugees, and in excess of \$125 million in property damages including 15 bridges destroyed and 39 others damaged. Damages were caused by floods following torrential rainfall. The heavy rainfall combined with shallow channels and steep gradients resulted in floods of record heights in many areas, with structures of all kinds heavily damaged by water, mud, silt, debris, and erosion. Damages to streets and roads consisted of wash outs, eroded shoulders, shoaled-up culverts, rock and gravel slides, erosion, and extensive pot holes. In Mayagüez, at Guanajibo Homes, one street was completely excavated for several blocks in length and 3 meters deep. Road damages in the region were estimated at \$40 million. Table 7 shows some damages reported for different flood events in the Hormigueros area and for the September 1975 flood event in the Guanajibo Homes housing development. Damages reported refer almost exclusively to structure contents. It is understood that damage assessments during emergency conditions do not follow a rigorous procedure of information compilation; thus, historical damages shown (specially at Guanajibo Homes) are grossly underestimated and are included as a general reference only. Appendix E, Economic Analysis, provides additional information on damages associated with the 1975 floods.

4. Floodable areas. The floodable areas for existing conditions in the detailed study area are shown on Plate 2. Table 8 summarizes the number of structures subject to flooding in the detailed study area for selected flood frequencies. Appendix E, Economic Analysis, provides a detailed description of affected property.

The Mayagüez, Hormigueros, and San Germán urban areas are affected by overflow of the Río Guanajibo. The 100-year flood event would inundate about 737 acres of urbanized areas. Most of the areas affected are residential, commercial, and public facilities. Traditionally, the areas most frequently affected by flooding are: Guanajibo Homes and San José at Mayagüez; Valle Hermoso and Parcelas San Romualdo at Hormigueros; and Santa Marta (Riverside), Urb. Vivoni, and part of Porta Coeli development at San Germán.

In the Mayagüez-Hormigueros area over 50 commercial establishments are located within the 100-year flood plain, most of which are medium sized outlets located along major streets and primary

TABLE 7
RIO GUANAJIBO FEASIBILITY STUDY

HISTORICAL DAMAGES¹

FOR THE CITY OF HORMIGUEROS (GUANAJIBO, VALLE HERMOSO SECTOR)	
FLOOD EVENTS	TOTAL DAMAGES
September 1975	\$9,443,976
August 1979	1,163,493
September 1982	21,000
September 1984	26,000
May 1985	46,475
October 1985	419,000
FOR GUANAJIBO HOMES IN THE CITY OF MAYAGUEZ	
FLOOD EVENT: September 1975	
DAMAGE CLASSIFICATION	AMOUNT REPORTED ² (Dollars 1975)
Residential for Guanajibo Homes (Contents)	\$ 39,122
Other Damages:	\$103,573
Municipal Vehicles	14,080
Heavy Equipment	29,700
Debris on the Bank	2,200
Debris from Guanajibo Homes, Guanajibo Gardens, Parcelas Castillo, and El Maní	57,593
Aqueduct and Sewers Authority	8,752
Total Damages:	\$151,447

¹Civil Defense, municipal governments of Hormigueros and Mayagüez.

²Amounts reported do not include damages to streets, roads, and structures.

TABLE 8

RIO GUANAJIBO FEASIBILITY REPORT

DISTRIBUTION OF STRUCTURES AFFECTED BY SELECTED FLOOD FREQUENCY
AND PRINCIPAL LAND USE CATEGORY
FOR EACH OF THE STUDY AREAS

MAYAGUEZ AND HORMIGUEROS AREA		
LAND USE	25-YEAR	100-YEAR
Residential	1,989	2,234
Commercial	40	52
Public	14	14
Non-Profit	11	11
Utilities	10	10
Total	2,064	2,321
SAN GERMAN AREA		
Residential	408	502
Commercial	15	47
Public	12	20
Non-profit	12	2
Utilities	7	7
Total	444	578

highways. Some 47 public and non-profit facilities are also subject to flooding. Within the flood plain in the San Germán area there are some 47 commercial structures and several public and non-profit facilities.

5. Potential flood damage. Table 9 summarizes potential flood damages under existing conditions for the two detailed study areas for selected flood frequencies and principal land. These damages are computed on the basis of historical flood damage relationships developed for comparable property throughout Puerto Rico. Details on the development and application of these relationships by major land use are presented in Appendix E, Economic Analysis.

For the Mayagüez-Hormigueros area the 100-year flood along Río Guanajibo would result in \$50.9 million in damage. Average annual damage for existing conditions is \$4.8 million, while average annual equivalent damage as of base year is \$5.4 million.

The San Germán area has an estimated \$18.4 million in damage for the 100-year flood. Average annual damage for existing conditions is \$1.1 million, while average annual equivalent damage as of base year is \$1.2 million.

In both areas most of the damage is sustained by residential developments.

6. Flood warning system. The P. R. National Civil Defense currently operates the Automated Local Evaluation in Real Time (ALERT), a flash flood warning system installed in 18 of the largest watersheds in Puerto Rico. ALERT consists of a network of rain gages together with stage-discharge sensors throughout the island providing real time rainfall-runoff data which is transmitted by a satellite telemetry system which allows monitoring the behavior of selected streams with data updates every five minutes. ALERT is jointly operated by the Civil Defense, the U. S. National Weather Service, and the U. S. Geological Survey Water Resources Division.

In the Río Guanajibo basin the ALERT network consists of a total of 5 rain gages and 2 stage-discharge sensors (refer to Figure 7). The Río Guanajibo ALERT system is very effective in providing advanced flood warning for the densely populated areas within its lower flood plain. A flood control project in the flood plain would have no adverse impact on the ALERT system. The ALERT system could be utilized to complement proposed flood control measures for the study area.

B. Water Supply

The PRASA is the local government agency responsible for providing water and sewer service to all residents of the island. PRASA's existing and future investment program is based on the Island Wide Water Supply Implementation Plan (IWSIP) Study developed by the consulting firm of Santiago-Vázquez Flaherty & Giavara (1983). This report based much of its analysis and recommendations on the Island Wide Water Supply Study (IWWSS) completed by the U. S. Army Corps of Engineers in September of 1980. The objective of the IWSIP was to identify the water supply projects required to meet the existing and projected demand, up to the year 2020. The Mayagüez Planning Area, as defined in the IWSIP

TABLE 9
RIO GUANAJIBO FEASIBILITY REPORT

POTENTIAL DAMAGE FOR SELECTED FLOOD EVENTS
1994 WITHOUT PROJECT CONDITIONS
FOR THE MAYAGUEZ-HORMIGUEROS, AND SAN GERMAN AREAS
(\$1,000 of 1994)

MAYAGUEZ-HORMIGUEROS AREA			
LAND USE	FLOOD FREQUENCY		
	2-YEAR	25-YEAR	100-YEAR
Residential	\$699	\$26,858	\$42,283
Commercial	0	2,820	5,570
Public	0	371	539
Non-profit	0	59	96
Streets/Highways	43	158	187
Utilities	172	1,443	2,264
Total	\$914	\$31,709	\$50,939
Average Annual Damage: \$4,821			
SAN GERMAN AREA			
Residential	\$0	\$7,472	\$11,124
Commercial	0	1,412	5,224
Public	0	535	1,244
Non-profit	0	19	35
Streets/Highways	0	67	317
Utilities	8	255	476
Total	\$8	\$9,760	\$18,420
Average Annual Damage: \$1,117			

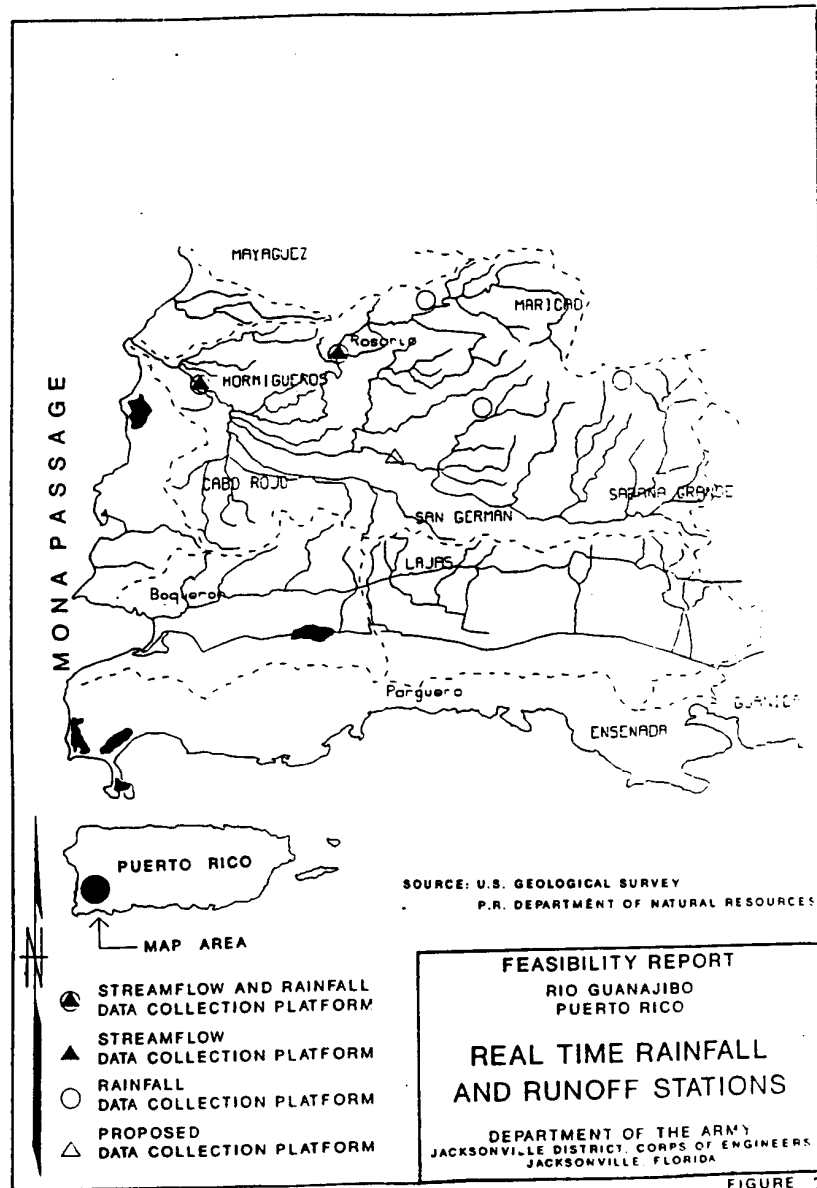


FIGURE 7

study, includes the municipalities of Añasco, Mayagüez, Hormigueros, San Germán, Sabana Grande, Lajas, and Cabo Rojo. The IWSIP study concluded that "the Mayagüez region has adequate water resources which can be developed within the planning period (1980 to 2020) to supply the projected water need... Additional water resources, specifically the Rosario (a Río Guanajibo tributary) and Yagüez reservoirs (potential), although not cost effective for implementation within the planning period, are available for future development..." The study recommends the development of a wellfield and a filter plant within the Río Guanajibo valley. According to the Puerto Rico Environmental Quality Board (EQB), the limestone and alluvium in the Río Guanajibo valley are thought to be the greatest untapped sources of ground water in the southwest.

In September 1987 the DNER prepared a report on water supply demand and availability for the island, Situación y Perspectiva de la Demanda y Oferta de Agua en Puerto Rico Servida por la AAA. The report concluded that water supply capacity for the Mayagüez region exceeds the demand; and, therefore, no major water supply project was recommended for the area. The report also concluded that efforts should be directed towards increasing water supply efficiency to minimize losses in the distribution system. However, during the last few years PRASA has expanded considerable ground water development in the area.

C. Water Quality

According to the EQB, water in the Río Guanajibo basin presents a high total coliform, thus, constituting a public health hazard. Nearly all of the tributaries of Río Guanajibo violate the coliform standards by at least a factor of 5. On the other hand, nearly none of them has a high BOD or a low oxygen content.

According to the USGS, the chemical quality of the surface water in the valley makes it suitable for most industrial, domestic, and agricultural uses. Data shows that the waters are of the calcium-magnesium bicarbonate types and moderately soft. On the other hand, the limited available information indicates that ground water is generally suitable for most purposes. There was no evidence of high salinity concentrations.

D. Land Use

The topographic restrictions of the region have considerably limited the growth of the urban areas of Mayagüez, Hormigueros, and San Germán. The floodable area and the steep topography are physical barriers that have limited the growth of these populated areas. Urban growth has spread to areas adjacent to the urban core and built-up areas along PR Highway 2.

As population increases in the future, the demand for additional lands for development would significantly increase. The Puerto Rico Planning Board (PRPB) intends to accommodate this development by increased densification in the already developed areas and by permitting additional developments in some of the uplands.

E. Soil Erosion

The Central Mountain Range of Puerto Rico is comprised of igneous and sedimentary rocks. The intensive processes of chemical weathering which characterizes the humid tropical climate have produced moderate and deep soil profiles, which fail during prolonged period of rainfall. The areas in which deep soil profiles are encountered over intrusive rock are very unstable. The most common movements experienced in this physiographic province are small landslides and soil, rock, and debris flows. North and south of the range there are bands of limestone which originated in the Middle Tertiary Age. These soluble rocks are characterized by complex underground drainage systems. The dissolving action of the water on the limestone accelerates the weathering in the upper areas of the basin. In accordance with the USGS, the Río Guanajibo valley is essentially an anticline that has been breached by erosion and is bounded in part by faults and partially filled by Quaternary alluvium. The soils in the valley are deep, moderately permeable, and slightly acid. Erosion is not considered a hazard in the soils of the valley.

F. Sediments

Río Guanajibo flood plain is about 27 kilometers long and is divided into two fan-shaped valleys. The "neck" between the two valleys is located just upstream PR Highway 100. The width of the fan-shaped valley upstream PR Highway 100 varies from about 0.6 kilometers between the towns of Sabana Grande and San Germán to about 5.2 kilometers in the Cabo Rojo and Hormigueros region. The width of the costal valley (project area) varies from 0.4 kilometers at PR Highway 100 (the "neck") to about 2.8 kilometers in the costal area. Main tributaries to Río Guanajibo, to include Río Rosario, pour their waters into the valley upstream PR Highway 100. Most of the sediment load transported by Río Guanajibo and its tributaries will tend to be deposited within the upper valley before reaching the project area.

The U. S. Soil Conservation Service (USSCS) in its report, Watershed Work Plan, Bajura Watershed, October 1961, states based on historical information that "sediment damages in the flood plain are relatively insignificant. The sediment which originates on the slopes both north and south of the flood plain consists of fine materials. It is carried in suspension and will settle out as channel fill or overbank deposition only when the floodwaters are held back for several days. Channel fill is a recognized problem only in the flood plain areas served by the Quebrada Maga and the Río Viejo. Spoil bank accumulations along many of the channels in this areas indicate that frequent ditch clean outs are necessary". Based on this information and experience in the area, we can assert that most sediments deposition in the valley associated with flooding events occurs several hours after the peak discharge has passed. The main concern associated with sediment-erosion damages discussed in the USSCS report is related "swamping". "Each year more land is swamped and taken out of production...." The expansion of wetlands in the lower valley is associated with predominant low land levels and lack of adequate drainage. Historically, in this predominant agricultural valley, significant sediment depositions with associated damages to crops and clearing requirements have not been identified as major concern.

A sediment impact assessment for Río Guanajibo was prepared by the U. S. Army Corps of Engineers, Waterways Experimental Station, in January 1994. The study concluded that proposed levee project should not affect current sediment conditions nor increase maintenance requirements within the Mayagüez-Hormigueros study area. The sediment impact assessment report is included in Appendix A, Hydrologic and Hydraulics.

G. Recreation

A variety of recreation opportunities currently exist in the proposed project area. Several beaches for swimming in the Mayagüez area attract the general public; there are athletic fields within easy travel distance; there is fishing in the streams near their confluence with the ocean; and private recreational facilities are available. Recreational opportunities created by the proposed flood control projects are examined.

V. PLAN FORMULATION RATIONALE

A. General

Plan formulation involves the identification, analysis, and evaluation of alternative flood control management plans that address the planning objectives within a set of constraints, assumptions, and criteria.

This report analyzes flood control alternatives for the area of Mayagüez-Hormigueros and the area of San Germán. Alternatives for each area are examined separately.

B. Planning Objectives

It has been established that there is a critical flooding problem in the lower and mid Río Guanajibo basin that seriously affects the safety and well-being of thousands of families in the municipalities of Mayagüez, Hormigueros, and San Germán. Consequently, the overall goal guiding this report is formulating flood control plans for these areas that will protect the lives and property of the families and will enhance the study area's economic base to sustain future economic development.

The specific objectives are:

- Safeguard the lives of the persons living within the flood plain of the Río Guanajibo.
- Provide for the preservation of the existing wetlands, critical wildlife habitats, and cultural resources in the study area.
- Minimize potential financial and personal property losses from inundation damages.
- Minimize disruption of economic and social activities.
- Enhance opportunities for further regional growth.

- Identify opportunities for additional outdoor recreation areas and activities.

C. Planning Constraints

Several environmental and physical features in the flood plain pose limitations to the type and alignment of flood control works that could be considered. The plan formulation process was framed by the following conditions:

- Flood control alternatives for San Germán should consider water velocities in the area. During the September 16, 1975 floods, erosion of river embankments caused significant damages upstream PR Highway 119.
- The PR Highway 119 bridge has very limited capacity.
- The Mayagüez-Hormigueros area presents complex drainage characteristics. Low land with poorly drained soils, high ground water table, and swamp areas (most of it brackish water) are predominant physical characteristics for this area.
- The outlets of Caño Corazones, Caño Majagual, and Río Guanajibo frequently are partially blocked by sandbars from a south ward littoral drift along the coastal line.
- Flood control measures may restrict the floodway downstream PR Highway 100. Care should be taken to ensure that recommended flood control works do not cause adverse effects on the flood plain.
- The lower Río Guanajibo valley contains a significant amount of valuable environmental resources and wildlife habitat. Any flood control measure must consider the interactive relation among these systems and minimize possible adverse impacts.
- Applicability of nonstructural measures to provide protection to existing developments is impaired because of most of the construction being concrete, high urban density, and costly real estate.
- A significant number of archeological and historical sites have been identified within the lower valley.

D. Planning Assumptions and Criteria

Several engineering and economic assumptions and criteria were established to guide the plan formulation and evaluation process.

1. Engineering

a. Plans are developed separately for the Mayagüez-Hormigueros area and the San Germán area, and each plan must be complete in itself.

b. High discharges in the San Germán area require that degree of protection and type of design minimize potential for catastrophic results should project works fail.

c. The design flood is based on most probable future hydrologic conditions.

d. Proposed plans should minimize flood damages with a minimal impact on stages in areas outside the range of the flood control work.

e. Earthen levees were designed to have an alignment which would minimize real estate requirements and minimize impacts to environmental and cultural resources in the area.

f. Gabion mattress armoring was considered for the levee side slopes in areas where high flow velocities are expected or where real estate requirements could be minimized by providing steep channel side slopes.

g. Flood control measures should minimize impacts on wetlands particularly the areas in the vicinity of San José and Guanajibo Homes.

h. Flood control measures should minimize impacts on freshwater flow from the Merle Marsh to Caño Corazones mangrove forest.

i. Flood control measures should avoid excessive drainage of the Merle Marsh.

j. Risk-based analysis on selected hydrology, hydraulics, and economic variables was applied to ascertain optimum scale of the plan of improvements and the hydraulic performance of the plans.

2. Economic and financial

a. Plans are evaluated separately for the Mayagüez-Hormigueros and the San Germán areas. Each plan must be justified in itself and each separate element of a plan must be incrementally justified.

b. For purpose of optimization of net National Economic Development (NED) benefits, not only are different plans for same degree of protection examined but similar plans are examined for different degree of protection.

c. Total beneficial contributions of each plan considered must exceed the total adverse impacts, and one of the plans must maximize net NED benefits.

d. The study year is taken as 1994, the base year as 2000, and the end of the planning period as the year 2050.

e. Increase in annual damage from existing conditions only reflects application of the affluency factor to contents of residential development under existing conditions. A factor of 3.4 percent was

estimated using socioeconomic statistical data provided by the PRPB. A limit of 50 percent of structure value is imposed to the value of residential contents by regulations presently in force.

f. Plan optimization was based on environmental concerns and the potential for reduction of inundation damages.

g. Risk-based analysis on selected hydrology, hydraulics, and economic variables was undertaken to support the scaling of the plan of improvement.

E. Without Project Conditions

The without project conditions scenario would be equivalent to the no action plan, which envisions no flood control works within the detailed study area.

Potential flood hazard to the life, health, and property of the residents in the area would remain as the most critical water-related problem. Periodic disruption of productive economic activities resulting from flooding in the area would impair further economic development.

Following the present demographic trend, the population of the municipalities of Mayagüez and Hormigueros is expected to increase from about 115,600 inhabitants in 1990 to about 142,000 inhabitants by the year 2000. The Municipality of San Germán is expected to increase from about 35,000 in 1990 to about 40,000 inhabitants in the year 2000.

In terms of economic development, the future growth of the study area would depend on the success of the Commonwealth and municipal government programs to induce higher capital investment in agriculture, manufacturing, and trade. Some factors that impact on future economic development in the area are the new local Industrial Incentives Act, the reduction in interest rates, the stability of crude oil prices, and the preservation of tax benefits under Section 936 of the United States Internal Revenue Code.

The manufacturing, commerce, services, and government activities are expected to remain as the most important source of income and employment in the study area. The construction sector is also expected to make a significant contribution to future economic development. The improvements of the existing highway network, new housing developments, shopping malls, fast food centers, and the expansion of existing facilities and infrastructure would contribute to the growth of the area. Construction of new traffic lanes on PR Highway 2 and improvements to PR Highway 102 have been initiated in Mayagüez, and a new shopping mall is on its first construction phase.

Since the city of Mayagüez constitutes the growth center of the study area, the PRPB adopted in 1975 and revised in 1992 the Urban Land Use Expansion Plan for the city and its metro area. Major tourism projects and new housing developments are expected to begin construction within the next few years.

VI. PRIOR STUDIES AND REPORTS

Numerous flood control studies have been undertaken within the Río Guanajibo basin. Most of them have addressed flooding problems in a particular sector of the flood plain. The only previous comprehensive study in the area was conducted in the early 1960's by the U. S. Soil Conservation Service (SCS).

In October 1961 the SCS initiated a comprehensive flood control study for the entire watershed under the authority of the Watershed Protection and Flood Prevention Act, PL-566, as amended. The emphasis was initially the protection of agricultural lands. Later, consideration was given to provide 100-year flood protection to urban areas along the main river channel. The plan included land treatment measures and a combination of levees and channel improvements for flood control and drainage. Multiple institutional limitations kept the SCS from implementing any of the proposed work. In 1978 the SCS revised original study and found that though the project was still economically feasible, required investment would have precluded initializing any other work under PL-566 in Puerto Rico. Since the Guayanés project in Yabucoa and the Río Añasco project were in advanced design stage under the same authority, the Commonwealth Government decided to request SCS' support for these areas and to request the U. S. Army Corps of Engineers' assistance in developing flood control alternatives for the Río Guanajibo valley.

In 1964 the consulting firm of Kenneth E. Madsen prepared for the PRPB a flood control study for Río Yagüez and Río Guanajibo to reduce flood damages and to provide additional land for urban and industrial expansion for the Municipality of Mayagüez.

In 1972 the USGS prepared a Hydrologic Investigation Atlas on floods for the Río Guanajibo valley. The report depicts areas flooded during the July 30, 1963, flood. Also, information on some historic floods was included. In 1982, as a consequence of the last devastating floods caused by torrential rains associated with the passage of Hurricane Eloise near the north coast of Puerto Rico within September 15-17, 1975, USGS published a flood atlas documenting this extraordinary event.

In 1974 the consulting firm of Flavio Acarón and Associates prepared for the Puerto Rico Highways Authority a hydraulic study to determine the effects the proposed PR Highway 101 embankment and bridge over the Río Guanajibo would have on the floods levels at the town of San Germán and its vicinity.

In 1978 the DNER initiated a flood insurance study for the Federal Insurance Administration. The study, which was first published in 1978 and later revised in October 1980 and in December 1983, covers all significant flooding sources affecting the valley.

In 1978 the U. S. Army Corps of Engineers conducted at the request of the Puerto Rico Industrial Company a reconnaissance study on floodings at the town of Maricao. This study showed that flooding problems were basically at the Travenol Labs., Inc. industrial plant and that flooding to other areas was minimum. The benefit to cost ratio for the proposed

improvements were marginal (1.2/1.0), and the principal beneficiary would be a private commercial entity. It was decided not to continue into the next feasibility phase.

Also, in 1978 and at the request of the Mayor of Sabana Grande the U. S. Army Corps of Engineers conducted a Section 205 reconnaissance study for the town of Sabana Grande. Detailed project report for solving the problem of the town was completed in June 1984 and construction completed in July 1989.

In 1979 the firm GDA Consulting Engineers prepared a study for the Puerto Rico Highways Authority on measures for the PR Highway 102 along the Río Guanajibo flood plain.

Also, in 1979 the Puerto Rico Industrial Development Company contracted the consulting firm of Bermúdez and Beniamino to prepare a hydrologic study in the vicinity of Río Guanajibo to provide flood protection to a parcel of land owned by the company south of PR Highway 101 in the Municipality of Mayagüez.

In 1981 the firm Jaime Fuentes and Associates, under a contract with the DNER, completed a flood control study for the lower Río Guanajibo flood plain. The scope of the study was to develop flood control measures for the area downstream of PR Highway 100. Major improvements recommended consist of various configurations of levees, channel improvements, and flow diversion. The study also considered three reservoir sites in the upper basin for flood control and water supply. The report concluded that a combination of a levee system from PR Highway 100 to PR Highway 102 channel improvements with levees for Río Hondo and Caño Majagual, Quebrada Sábalo and Caño Merle, and a ring levee for Guanajibo Homes development represented the most economical solution to the flooding problem in the area.

As part of its flood control and bank stabilization program, the DNER designed and constructed in 1993 a gabion-lined project along Río Guanajibo in the vicinity of the town of San Germán. Specifically, the project consists of about 600 meters of gabion-lined bank stabilization and erosion control project on the south bank upstream PR Highway 119 to protect the Santa Marta and Riverside developments river bank. The project does not provide significant flood control in the area. This is due to the existing PR Highway 119 bridge that controls the hydraulic capacity of the river channel in the San Germán area. The improvements, however, are incorporated into the flood control plans proposed for the San Germán area as part of this report.

VII. FORMULATION OF PRELIMINARY PLANS

A. Identification of Relevant Measures

Four nonstructural measures and three structural measures were identified to fully or partially address planning objectives. The nonstructural measures considered are flood plain management, flood insurance, temporary and permanent flood plain evacuation, and channel

maintenance. Structural measures considered include channel improvements, floodwalls, and levees. Measures considered are described in the following paragraphs:

1. Nonstructural measures.

a. PRPB Regulation 13. The most important and relevant nonstructural measure to regulate development in the flood plain is the PRPB Regulation 13. This regulation, which predates FEMA flood plain regulations and which in 1987 was revised to make it consistent with FEMA, regulates all new developments and expansion of, or improvements to, existing developments in flood prone areas. For a developer to receive a construction permit in a flood prone area he must establish through a hydrologic and hydraulic study that his project is above the 100-year flood event or that it will not raise water stages in the vicinity by more than 0.3 meters. Flood plain management regulations are assumed to be in effect under all plans. Flood plain management, however, will have very limited effect in reducing potential flood damages to existing developments.

b. Flood insurance program. The National Flood Insurance Program (NFIP) is administered by the Federal Flood Insurance Administration (FIA), which is part of the FEMA. The PRPB serves as the local coordinating agency for the Flood Insurance Program in Puerto Rico. Puerto Rico entered the Emergency Flood Insurance Program (EFIP) in 1972 and entered the Regular Flood Insurance Program in 1978. For purposes of the Flood Insurance Program, Puerto Rico is considered a single community.

Flood insurance would not reduce or eliminate the flooding problem but it would serve to reimburse property owners for losses incurred. The measure, however, seems to have been of very limited acceptance in Puerto Rico because due to the frequent and significant flood damages, insurance premiums tend to be high. However, participation rate is expected to increase because the insurance is an important requisite for any economic transaction that would relate to Federal funds.

c. Temporary and permanent flood plain evacuation. Temporary evacuation of persons and personal property from flood prone areas could be accomplished when a flood threat exists. Temporary evacuation can be very effective when operated in conjunction with a reliable flood warning system and where mobile, damageable objects are a significant portion of personal property.

The ALERT system described in section IV.A.6. is currently in operation for the Río Guanajibo basin and could be utilized to complement proposed flood control measures for the study area.

Permanent evacuation of the flood plain areas could be used to reduce flood damage potential. Such a measure involves land purchase, physical removal of buildings and infrastructure, and relocation of population. Lands acquired in this manner could be used for parks or other purposes that would not interfere with flood flows or receive material damage from floods. As part of the reconnaissance study, the permanent relocation of Guanajibo Homes, in the lower valley, was

considered in the plan formulation. However, the permanent relocation of 272 housing units with all the communal facilities and 12 commercial and industrial outlets within a highly urbanized area of a major city is to a large extent impractical and would have very little acceptance. Therefore, permanent evacuation was not considered any further.

d. Stream clean out program. This measure primarily consists of removal of trash, debris, and sediments from the existing stream channel. Though minimal, this measure contributes to all objectives, especially for high frequency floods. This should be a recurring activity every two years.

2. Structural measures

a. Channel improvements. Since this is very effective at reducing flood damages, this type of measure was considered for the Mayagüez-Hormigueros and for the San Germán area. However, the use of concrete lining in a environmentally sensitive area, like the lower valley, represents a significant adverse impact beyond economical considerations. Therefore, concrete channels in the lower valley were not considered.

b. Floodwalls and levees. These measures preclude floodwater from entering flood prone areas. Since they have proved to be very effective in areas where there is enough open space to accommodate them, without impacting significantly areas out of the protective measure, these measures were considered for both detailed study areas. Floodwalls, although more expensive, have less land requirements than levees and, therefore, the impacts on wetlands should be considered as a minimal requirement for flood protection.

B. Description and Evaluation of Preliminary Plans

1. General. Preliminary flood control plans are developed separately for the Mayagüez-Hormigueros area and the San Germán area. In the case of the Mayagüez-Hormigueros area, three plans, each protecting against the 100-year flood, were examined. The plans combine floodwalls and levees along the southern fringe of existing developed areas, channel improvements along several of the streams and canals in the area, and improvements to the flood plain conveyance in selected areas. For the San Germán area, four levees and channel improvements plans are analyzed for various degrees of protection.

2. Description of Preliminary Plans

a. Mayagüez-Hormigueros area

(1) Plan 1. The plan consists of 8.4 kilometers of levee and 900 meters of floodwall system extending along the southern edge of the Mayagüez-Hormigueros area from the coast to 1.8 kilometers upstream PR Highway 100 and limited channel improvements to Río Hondo. It is designed to provide 100-year flood protection (Plates 3A and 3B). A concrete floodwall would begin at PR Highway 102 just south of the San José development. It would extend for 900 meters along the southern and eastern border of the development. Then an earthen levee will follow turning and continuing in a southeast direction, just south of the

developed area along PR Highway 2, for about 3.1 kilometers to its intersection with the west bank of Río Hondo. The main levee would resume on the east bank of Río Hondo and would continue eastward about 1,500 meters to an urban development which was built on a previously existing knoll above the 100-year flood event just west of PR Highway 100. A short section of levee would then be required to connect the east side of the development with the PR Highway 100 bridge approach. Construction of the main levee would then be continued on the east side of the PR Highway 100 bridge approach and would extend along the south edge of PR Highway 309 for about 900 meters to the west bank of an unnamed tributary. The levee would resume on the east side of the tributary and would continue another 900 meters to tie into high ground just north of PR Highway 2. At the two points where the levee is interrupted by tributary inflow, tie-back levees would be required. On the smaller unnamed tributary, the levees would extend along both banks from the main levee northward about 900 meters to high ground just south of PR Highway 114.

A trapezoidal borrow canal would be constructed along the main levee to a common outlet with Caño Majagual with a total length of 3.7 kilometers. Side slopes would be 1 on 4 and bottom width ranging from 1.5 meters at the upstream end of the canal to 30.5 meters at the outlet with Caño Majagual.

The Guanajibo Homes development would be protected by a ring levee about 1.1 kilometers long with a uniform crest elevation of 4.3 meters (NGVD). This corresponds to an average levee height above existing ground of about 3.5 meters. Levee side slopes would be grass-lined for the entire length. The PR Highway 102 bridge over Río Guanajibo would be replaced as part of this plan.

In addition to the tie-back levees proposed along Río Hondo, channel improvements are recommended for this tributary from its intersection with the main levee northward to PR Highway 2. At the levee, the improved channel would be trapezoidal with a 30-meter bottom width and 1 on 4 grass-lined side slopes. Channel improvement would be continued upstream for 600 meters where a transition from trapezoidal to vertical-walled channel would begin. This 100-meter transition would result in a vertical-walled, gabion-lined channel with a 30-meter bottom width. The vertical-walled channel would continue about 600 meters further upstream ending just south of PR Highway 2. Proposed improvements would also require construction of a new bridge over Río Hondo at PR Highway 114.

The total first cost of this plan is \$30.13 million with annual cost of \$2.65 million, annual inundation reduction benefits of \$5.26 million, and a benefit to cost ratio of 1.98/1.0.

(2) Plan 2. This plan consists of a levee and floodwall system designed to provide 100-year flood protection similar to Plan 1 but with a variation downstream from the Río Hondo intersection (Plates 4A and 4B). Plan 2 avoids cutting off part of the Merle Marsh from the river's overflow. The San José development would be protected by both a floodwall and tieback levee similar to Plan 1. However, after the floodwall that surrounds the development, an earth levee would continue from station 10+00 in a southeasterly direction parallel to Quebrada

Sábalos for about 670 meters and tie into existing high ground at station 15+70. Crest elevation of this floodwall and levee structure is about 5.6 meters (NGVD). Channel improvements and replacement of PR Highway 102 bridge over Caño Majagual are also included as part of this plan. This improvement is an integral part of the levee system to protect the San José and Ramírez de Arellano developments. Proposed canal would have a total length of about 1.3 kilometers, side slopes of proposed canal would be 1 on 4 and bottom width ranging from 6 meters at the upstream end of the canal to 18 meters at the mouth. Upstream the Merle Marsh, a levee would provide protection to the industrial park and a small community to the west bank of Río Hondo, referred to as Parcelas Castillo. The levee would tie into existing ground about 400 meters south of PR Highway 2 and 430 meters south and away of the marsh. It would extend in a westward direction parallel to Río Hondo for about 800 meters. Then, the levee would turn in a southwesterly direction for 400 meters prior to turning in a southeasterly direction for another 700 meters to intersect with the west bank of Río Hondo. The levee would resume on the east bank of Río Hondo and continue southeastward to PR Highway 100 and towards PR Highway 2 similar to Plan 1. Río Hondo tieback levees and channel improvements are also similar to Plan 1.

The Guanajibo Homes development would be protected by a ring levee with a uniform crest elevation of 5.6 meters. The PR Highway 102 bridge over Río Guanajibo would not be replaced as part of this plan, for it does not significantly impact on the hydraulics of the area.

The total first cost of this plan is \$27.09 million with annual cost of \$2.39 million, annual inundation reduction benefits of \$5.25 million, and a benefit to cost ratio of 2.2/1.0.

(3) Plan 3. This plan consists of channel improvements for Río Guanajibo, a levee upstream PR Highway 100, and channel improvements for Río Hondo and the Caño Majagual system designed for the 100-year event (Plates 3A and 3B). The 1 on 3 trapezoidal channel would extend from the river outlet to about 1.5 kilometers upstream PR Highway 100 for a total length of 6.1 kilometers. The channel would have a bottom width of about 171 meters for the first 2.6 kilometers to end with a gabion-lined channel of about 47 meters bottom width for the remaining 3.4 kilometers. The channel would have an average water depth of 8.5 meters. Bridge improvements would be needed at PR Highway 102 over the river. The levee upstream PR Highway 100 would be about 1.4 kilometers long with an average height of 4.1 meters with no revetment required. As part of the levee protection to the community upstream PR Highway 100, there is an unnamed creek that would require 300 meters of channel improvements and levees on both sides with an average height of 3 meters. Upstream PR Highway 100, PR Highway 114 bridge would be removed and traffic would be re-routed through PR Highway 100 permanently. The interior drainage at Hormigueros would be accomplished by flap-gated culverts and a tie-back levee for the inflow.

The Río Hondo tributary would be enlarged from PR Highway 2 downstream to junction with Río Guanajibo for a total length of 1.3 kilometers with a 30 meters bottom width. The first 700 meters of channel improvements will consist of a 1 on 3 trapezoidal section with

a 4 meters average water depth and no revetment required. The remaining 580 meters would consist of a gabion-lined rectangular section with a 4 meters water depth.

Channel improvements to the Caño Majagual system consider connecting all three segments to a common outlet with no revetment requirements. The bridge over Caño Majagual at PR Highway 102 would be improved to accommodate the 17 meters bottom with 1 on 3 section and about 600 meters long channel that would serve as common outlet for the system. Caño Majagual would connect to this channel with a 9 meters bottom width, 1 on 3 side slope, and about 1 kilometer long channel, with an average depth of flow of 2.5 meters. Quebrada Sábalo follows with a 10 meters width and 1 on 3 side slope channel of about 1 kilometer long with 2.5 meters depth of flow. To complete the system, Caño Merle would connect with also a 10 meters bottom width and 1 on 3 slope channel of about 1.4 kilometers long and 3 meters water depth.

The total first cost of this plan is \$82.06 million with annual cost of \$ 7.56 million, annual inundation reduction benefits of \$5.26 million, and a benefit to cost ratio of 0.70/1.0.

b. San Germán Area

(1) Plan 1. This plan consists of concrete rectangular channel and levees designed for the 100-year event (Plate 5). The concrete channel with a bottom width of 30 meters and 6.2 meters of normal water depth would start about 50 meters downstream PR Highway 360 and would extend about 360 meters upstream PR Highway 119. Upstream the concrete channel a 32 meters bottom width gabion-lined trapezoidal channel and levees with side slope of 1 on 3 follows for about 100 meters. This would transition to a trapezoidal channel with natural bottom and gabion side slope for about 270 meters to terminate at a gabion cut-off wall of 2 meters deep. A 350 meters long with an average width of 150 meters and 1 meter depth debris catchment would complete this plan. All four inflow locations would require flap-gated culverts. A stilling basin would be included downstream the concrete channel to reduce energy from the concrete lined reach. The plan also calls for gabion-lined levees on both banks downstream PR Highway 360. The south bank levee would extend along PR Highway 347 for about 1.3 kilometers with an average height of 3.5 meters and side slope of 1 on 3. On the north bank the levee would extend along PR Highway 360 for about 590 meters with an height of 5.2 meters and a 1 on 3 slope.

The total first cost of this plan is \$32.75 million with annual cost of \$2.86 million, annual inundation reduction benefits of \$1.25 million, and a benefit to cost ratio of 0.43/1.0.

(2) Plan 2. This plan consists of gabion-lined channel improvements and levees to provide protection against the 100-year flood (Plate 5). Channel improvements would start 600 meters downstream of PR Highway 360 to about 700 meters upstream PR Highway 119 for a total length of 2.2 kilometers. Improvements would follow basically existing channel except for the portion downstream PR Highway 360 where the channel will be realigned approximately 60 meters away from PR Highway 347. The channel would be trapezoidal with a 35 meters bottom width with a gabion-lined 1 on 3 side slope. The plan also calls for

gabion-lined levees on both banks extending along most of the proposed improvements. Downstream PR Highway 360 the south bank levee would extend along PR Highway 347 for about 1.3 kilometers with an average height of 3.5 meters and side slope of 1 on 3. On the north bank the levee would extend along PR Highway 360 for about 590 meters with an height of 5.2 meters and a 1 on 3 slope. Upstream PR Highway 360 gabion-lined levees would also be required on both river banks. The south bank levee would start about 150 meters upstream PR Highway 360 bridge extending about 1 kilometer with a height of 4.4 meters. The north levee would start about 50 meters upstream from same bridge extending about 1.3 kilometers with a height of 5.3 meters. The section at the PR Highway 119 bridge would require a 51 meters bottom width gabion rectangular section and a concrete pier extension to avoid bridge replacement. PR Highway 360 bridge would require channel clean out. Normal water depth for this plan is 7.5 meters. Three flap-gated culverts on the south levee and one same type culvert on the north levee would be required for interior drainage.

The total first cost of this plan is \$16.33 million with annual cost of \$1.46 million, annual inundation reduction benefits of \$1.22 million, and a benefit to cost ratio of 0.87/1.0.

(3) Plan 3. The plan consists of a levee system along both banks of the river designed to provide 25-year flood protection (Plate 5). The levee on the north bank would originate about 550 meters downstream from PR Highway 360 bridge and running parallel to same highway. The levee would continue on the north side of the channel, from the upstream side of the PR Highway 360 bridge approach, eastward about 200 meters where it would tie into existing high ground. Following this point, the levee would extend for 460 meters to PR Highway 119. The levee on the north bank would finish about 450 meters upstream from PR Highway 119 bridge. The levee on the north bank would have a total length of about 1.7 kilometers. The levee on the south bank would consist of three segments of levee similar to the levee on the north bank with a total length of about 1.5 kilometers. Gabion mattress protection would be required on the channel side along most of the levee length on both bank of the river.

The bridge at PR Highway 119 would be replaced. The bridge at PR Highway 360 would require channel clean out and gabion mattress erosion protection along the upstream pier extensions. Interior drainage would be accomplished through the placement of flap-gated culverts at five locations.

The total first cost of this plan is \$9.82 million with annual costs of \$869,000, annual inundation reduction benefits of \$878,000, and a benefit to cost ratio of 1.01/1.0.

(4) Plan 4. The plan consists of channel improvements and replacement of bridge at PR Highway 119 to provide protection against the 10-year flood. This plan does not include levee construction. Channel improvements would begin about 50 meters downstream of PR Highway 360 bridge to end about 700 meters upstream PR Highway 119 bridge (Plate 5) for a total length of 1.47 kilometers of channel improvements. The channel would be trapezoidal with a 65-meter bottom width and gabion-

lined side slopes. Scour protection would be provided on the channel bottom in the vicinity of PR Highways 119 and 360 bridges. Scour protection would also be provided at the upstream entrance to the channel.

The total first cost of this plan is \$7.30 million with annual cost of \$647,000, annual inundation reduction benefits of \$700,000, and a benefit to cost ratio of 1.08/1.0.

3. Evaluation of Preliminary Plans

All of the preliminary plans considered for the study area would result in some beneficial and some adverse impacts on the area's environmental and cultural resources. The final plan formulation process would investigate means to mitigate for any adverse impacts on the area's resources.

The most significant impacts deriving from the implementation of the preliminary plans would be those associated with the human, physical, and economic activities of the urban environment. These impacts relate to the protection of human lives and property from flooding and the sense of security granted to the residents within the study area, the changing of strips of natural vegetation along Río Guanajibo into an environment of channels and levees with some kind of fences for safety, and the support of a more attractive and productive economic environment. The implementation of the plans, on the other hand, would require the allocation of substantial economic capital resources that could be used to meet other social needs.

Generally, four types of environmental impacts would be associated with the implementation of the preliminary plans discussed above. During construction there would be some temporary impacts on air quality, water quality, and aquatic life and some permanent impact to wetlands in the area from clearing of vegetation and excavation for the construction of channels and levees, transportation of fill materials, and realignment of existing river channels in the vicinity of the project areas. Construction of the project would also entail considerable disruption of traffic and social inconveniences because the project requires the replacement of bridges within a highly urbanized area.

In the Mayagüez-Hormigueros area, the Merle Marsh provides an inflow of freshwater to the Caño Corazones mangrove forest and represents a significant portion of the entire wetland system within the flood plain. Plans 1 and 3 would disrupt that function by protecting the marsh from overflow of the Río Guanajibo. These two plans would also enhance several hundreds of acres of lands for which there will be a tremendous pressure from the private sector for development. Plan 2, on the other hand, avoids these adverse impacts. The plan avoids the Merle Marsh impacting other wetlands in the area and the potential enhancement of hundreds of acres of wetlands. Proposed channel improvements to Caño Majagual under Plan 2 are significantly reduced from those being proposed by Plan 1. Therefore, impacts to the mangrove forest in the Majagual outlet would be reduced by implementing Plan 2. Also, Plan 2 avoids replacing the PR Highway 102 bridge over Río Guanajibo and the PR Highway 114 over Río Hondo.

In the San Germán area, there are serious operational and safety concerns with the levee system proposed by Plan 3. A levee system with a low level of protection for a highly urbanized area may create a false sense of protection within the community. This, associated with the short reaction time that a major flood would provide for emergency operations, would create a very unsafe condition in case of levee overtopping.

Tables 10 and 11 summarize the most significant impacts associated with the implementation of each of the preliminary plans for the Mayagüez-Hormigueros and the San Germán detailed study areas.

On the basis of this analysis, preliminary Plan 2 in the Mayagüez-Hormigueros area and preliminary Plan 4 in the San Germán area are selected for further analysis.

VIII. DESCRIPTION AND ANALYSIS OF FINAL PLANS

A. General

The most attractive preliminary plan for the Mayagüez-Hormigueros area, Plan 2, was developed into three final plans for purpose of optimizing the NED plan between the 50-year (Plan 1F), the 100-year (Plan 2F), and the SPF (Plan 3F) level of protection. The best preliminary plan for the San Germán area, Plan 4, is presented as the only final plan (Plan 1F-SG) for that area, for it would take care of the most frequent flooding in the area. Further design refinements in accordance with an incremental analysis of every segment of the levee system plan for the Mayagüez-Hormigueros area will also be examined.

B. Description of Final Plans

1. Mayagüez-Hormigueros area

a. Plan 1F. This plan consists of a levee and floodwall system designed to provide 50-year flood protection similar to preliminary Plan 2 (Plates 4A and 4B). The Guanajibo Homes development would be protected by a ring levee with a uniform crest elevation of 5.0 meters (NGVD). The San José development would be protected by both a floodwall and tieback levee. After the floodwall that surrounds the development, an earth levee would continue from station 10+00 in a southeasterly direction parallel to Quebrada Sábalo for about 570 meters and tie into existing high ground at station 15+70. Crest elevation of this floodwall and levee structure is about 5.0 meters (NGVD). Channel improvements and replacement of PR Highway 102 bridge over Caño Majagual are also included as part of this plan. Upstream the Merle Marsh the main levee would provide protection to the industrial park and a small community on the west bank of Río Hondo. The main levee would resume on the east bank of Río Hondo and continue southeastward to PR Highway 100 and towards PR Highway 2.

The total first cost of this plan is \$18.44 million with annual cost of \$ 2.02 million, annual inundation reduction benefits of \$4.77 million, and a benefit to cost ratio of 2.36/1.0.

TABLE 10
RIO GUANAJIBO FEASIBILITY REPORT
COMPARATIVE ANALYSIS OF PRELIMINARY PLANS
(All Figures in \$1,000 as of 1993)
MAYAGUEZ-HORMIGUEROS AREA

	PLAN 1 100-YEAR	PLAN 2 100-YEAR	PLAN 3 100-YEAR
I. National Economic Development Effects			
A. Value of Increased Output of Goods and Services (Annual)			
1. Inundation Reduction Benefits	5,256	5,256	5,256
2. Residual Damages	482	482	482
3. Reduction in Property Losses	924	924	924
B. Value of Resources Required for the Plan			
Total Investment Cost	31,674	28,542	91,429
Annual Cost	2,649	2,393	7,555
Net Benefits (Annual)	2,607	2,863	(2,299)
Benefit/Cost Ratio	1.98/1.0	2.20/1.0	0.70/1.0
II. Environmental Effects			
A. Cultural	No significant potential impact on cultural sites in project area.	Same as Plan 1.	Same as Plan 1.
B. Flora and Wetlands	Destruction of vegetation along the valley. Impact on about 19.3 acres of wetlands along the levee. Merle Marsh would be cut off from flood plain. This will put a pressure on local government for development. Potential conflicts with EO's 11988 and 1999.	Impact on about 12.9 acres of wetlands. However, Merle Marsh would remain within the floodable area of Rio Guanajibo.	Same as Plan 1.

TABLE 10 (Cont.)
 RIO GUANAJIBO FEASIBILITY REPORT
 COMPARATIVE ANALYSIS OF PRELIMINARY PLANS
 (All Figures in \$1,000 as of 1993)
 MAYAGUEZ-HORMIGUEROS AREA

	PLAN 1 100-YEAR	PLAN 2 100-YEAR	PLAN 3 100-YEAR
C. Land Development	Would enhance for potential development hundreds of acres of wetlands and uplands currently in the flood plain.	Avoids enhancing floodable lands for future development.	Same as Plan 1 but on a larger scale.
D. Federal Threatened and Endangered Species	No impact to endangered species.	Same as Plan 1.	Same as Plan 1.
E. Noise	Temporary noise level increased during construction.	Same as Plan 1.	Same as Plan 1.
F. Water Quality	No impact to water quality.	Same as Plan 1.	Same as Plan 1.
G. Water Supply	No impact to surface waters.	Same as Plan 1.	Same as Plan 1.
Ground Water	Borrow channel is not expected to affect the aquifer.	Same as Plan 1.	Same as Plan 1.
III. Social Well-Being			
A. Life, health, and safety of residents	Will protect about 2,234 families.	Same as Plan 1.	Same as Plan 1.
B. Cohesiveness	Prevents disruption of family life in the detailed study area.	Same as Plan 1.	Same as Plan 1.

TABLE 11
RIO GUANAJIBO FEASIBILITY REPORT

COMPARATIVE ANALYSIS OF PRELIMINARY PLANS
(All Figures in \$1,000 as of 1993)

SAN GERMAN AREA

	PLAN 1 100-YEAR	PLAN 2 100-YEAR	PLAN 3 25-YEAR	PLAN 4 10-YEAR
I. National Economic Development Effects				
A. Value of Increased Output of Goods and Services (Annual)				
1. Inundation Reduction Benefits	1,245	1,219	878	700
2. Residual Damages	73	99	440	618
3. Reduction in Property Losses	94%	92%	67%	53%
B. Value of Resources Required for the Plan				
Total Investment Cost	34,535	17,421	10,259	7,674
Annual Cost	2,863	1,464	869	647
Net Benefits Effects (Annual)	0	0	9	53
Benefit/Cost Ratio	0.43\1.0	0.87\1.0	1.01\1.0	1.08\1.0
II. Environmental Effects				
A. Cultural	No high cultural site potential in project area.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.
B. Flora and Wetlands	No significant impact.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.
C. Federal Threatened and Endangered Species	No impact to endangered species.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.
D. Noise	Temporary noise level increased during construction.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.
E. Water Quality	No impact to water quality.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.

TABLE 11 (Cont.)
RIO GUANAJIBO FEASIBILITY REPORT
COMPARATIVE ANALYSIS OF PRELIMINARY PLANS
(All Figures in \$1,000 as of 1993)
SAN GERMAN AREA

	PLAN 1 100-YEAR	PLAN 2 100-YEAR	PLAN 3 25-YEAR	PLAN 4 10-YEAR
F. Water Supply				
Surface Water	No impact to surface waters.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.
Ground Water	No impact to ground water.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.
III. Social Well-Being				
A. Life, Health, and Safety of Residents	Will protect about 502 families.	Same as Plan 1.	Will protect about 408 families.	Will protect about 292 families.
B. Cohesiveness	Prevents disruption of family life in the detailed study area.	Same as Plan 1.	Same as Plan 1.	Limited effect.

b. Plan 2F. Same as Plan 1 but sized for the 100-year event. The elevation of the levee for the Guanajibo Homes-San José area will be 5.6 meters (NGVD), while for the Valle Hermoso-Buenaventura it will be 10.2 meters (NGVD) at levee station 33 + 00.

The total first cost of this plan is \$27.09 million with annual cost of \$2.39 million, annual inundation reduction benefits of \$5.25 million, and a benefit to cost ratio of 2.20/1.0.

c. Plan 3F. Same as Plan 1 but sized for the SPF event. The elevation of the levee for the Guanajibo Homes-San José area will be 6.0 meters (NGVD), while for the Valle Hermoso-Buenaventura area it will be 10.2 meters (NGVD) at levee station 33 + 00.

The total first cost of this plan is \$31.28 million with annual cost of \$2.80 million, annual inundation reduction benefits of \$5.51 million, and a benefit to cost ratio of 1.97/1.0.

2. San Germán area

Plan 1F-SG. The plan consists of channel improvements and replacement of bridge at PR Highway 119 to provide protection against the 10-year flood. Channel improvements would begin about 50 meters downstream of PR Highway 360 bridge to end about 700 meters upstream PR Highway 119 bridge (Plate 5). The channel would be trapezoidal with a 65 meters bottom width and gabion-lined side slopes. Scour protection would be provided on the channel bottom in the vicinity of PR Highways 119 and 360 bridges. Scour protection would also be provided at the upstream entrance to the channel.

The total first cost of this plan is \$7.30 million with annual cost of \$647,000, annual inundation reduction benefits of \$700,000, and a benefit to cost ratio of 1.08/1.0.

To bracket this plan at the lower end (the preliminary plans provide for bracketing it in the upper end) a 5-year channel improvement was investigated. It shows that the maximum annual benefits that it could provide will be about \$150,000, which when compared with a total investment of over \$5,000,000 equivalent to an annual cost of \$395,000 for the improvement will result in a negative NED benefit and benefit to cost ratio of less than 1.0. This validates the 10-year channel plan as the NED plan for the area.

C. Analysis of Final Plans

1. General. The purpose of this analysis is to arrive at a recommended plan on the basis of the contributions of the final plans to the planning objectives and the trade-offs among the plans.

2. Contributions to the planning objectives

a. Safeguard lives. Safeguarding the lives of some 2,736 families living along the Río Guanajibo flood plain in the areas of Mayagüez, Hormigueros, and San Germán is considered the ultimate objective of the proposed flood control project. A significant proportion of this population belongs to low-middle income families

striving toward improving their living conditions. All plans would contribute substantially to reduce the threat to life as a result of major floods in the study area. All plans for the Mayagüez-Hormigueros area provide 90 percent or more reduction of damages, and in that sense they are all very effective at minimizing property losses.

b. Minimize property losses. The criterion utilized to measure contribution of the plans to this objective was reduction of inundation damages. Total expected annual inundation damages under the without and with project conditions were estimated for each flood control plan. The plans considered for the Mayagüez-Hormigueros area would prevent from 83 percent under Plan 1F to 96 percent under Plan 3F of all the potential urban flood damages in the area. In this regard all plans considered for this area are effective in accomplishing this objective. In San Germán the plan considered would prevent 53 percent of all the potential urban flood damages for the area. Flood protection would not be afforded in this area to some 210 families.

c. Maximizing net economic benefits. Contribution to net national benefits in the Mayagüez-Hormigueros area varies from \$2,711,000 under Plan 3F to \$2,863,000 under Plan 2F (Refer to Table 12). Plan 2F maximizes the contribution of NED benefits for the area.

d. Minimize social disruption. This objective refers to minimizing adverse impacts on the normal daily economic and social life in the detailed study area. Whenever there is flooding in the area, indirect damage would result from reduction of business operations: thousands of persons unable to reach their jobs; hundreds of cars stalled in the middle of streets, avenues, and highways; recreational activities suspended; and reduction of other public services. The scope of services of agencies dealing with flood protection and relief in the areas affected (e.g. the Civil Defense, the Red Cross, etc.) is increased as well as isolation and social disruption of families. None of the plans analyzed involve significant relocations of families and/or the disruption of economic and social activities within the detailed study area.

e. Protecting the study area's environmental and cultural resources. All of the plans considered for the study area would result in some beneficial and some adverse impacts on the area's environmental and cultural resources. The recommended plan would provide means to satisfactorily mitigate all adverse impacts on the area's environmental and cultural resources. Generally, the three final plans for the Mayagüez-Hormigueros area have the same type of environmental impacts with the magnitude of the impacts increasing with the scale of design. Detailed discussion of project impacts to the environmental and cultural resources is presented in the Final Environmental Impact Statement (FEIS).

3. Incremental Analysis of Plans Elements

Incremental analysis was performed for each of the major elements suggested under each of the final plans for the Mayagüez-Hormigueros area. Table 12 shows the costs and benefits associated with each of the final plan, as well as for each major element under them. As a result of this analysis, levee sections in the vicinity of the

TABLE 12

RIO GUANAJIBO FEASIBILITY REPORT
SUMMARY BENEFITS AND COSTS OF FINAL PLAN AND THEIR PRINCIPAL ELEMENTS
(Annual Figures in \$1,000 of 1993)

MAYAGUEZ - HORMIGUEROS AREA

Elements	Damages w/o project	Plan 1F (50-Year Levee Plan)			Plan 2F (100-Year Levee Plan)			Plan 3F (SPF Levee Plan)		
		Benefits	Costs	Net Benefits	Benefits	Costs	Net Benefits	Benefits	Costs	Net Benefits
Guanajibo Homes & San José Developments	\$1548	\$1195	\$ 393	\$ 802	\$1365	\$ 473	\$ 892	\$1454	\$ 572	\$ 882
Caño Majagual Channel Improvements	50	50	116	(66)	50	126	(76)	50	127	(77)
Parcelas Castillo, Industrial area development and Rio Hondo Channel Improvements	19	3	484	(481)	11	567	(556)	15	656	(641)
Buenaventura, Valle Hermoso & San Romualdo Developments	4114	3520	797	2723	3825	950	2875	3987	1120	2867
Developments vicinity of Hwy 309	7	5	234	(229)	5	277	(272)	7	327	(320)
Total	\$5738	\$4773	\$2024	\$2749	\$5256	\$2393	\$2863	\$5513	\$2802	\$2711

SAN GERMAN AREA

	Damages w/o Project	Benefits	Costs	Net Benefits
Plan 1F (10-Year Channel Improvements)	\$1318	\$700	\$647	\$53
Plan 2F (5-Year channel Improvements)	1318	150	395	(245)
Plan 3F (25-Year Levee)	1318	878	819	9

industrial park and east of the unnamed stream at the end of the project (Highway 309), as well as the Río Hondo and Caño Majagual channel improvements were deleted from the final plans because they are not incrementally justified. The existing conditions of the areas for which improvements were deleted are not worsen as a result of implementing other elements under the final plans.

4. Summary Results of Conventional Analysis

On the basis of the above analysis, it is concluded that final Plan 2F (100-year) providing levees to protect only the areas of Guanajibo Homes/San José and Valle Hermoso/Buenaventura is the best and NED for those developments, while final Plan 1F-SG (10-year) channel improvement is the NED plan for San Germán. The combination of these two final alternatives for each of the separate areas of Mayagüez-Hormigueros and San Germán constitute the NED plan and is the recommended plan for the entire study area.

D. Risk Based Analysis of Final Plan

1. General. The primary purpose of the R&U based analysis was to better define the performance of each of the final plans in terms of the percentage chance of their being overtopped in any particular year. A secondary purpose was to conduct a sensitivity analysis to determine if there is any significant deviation from the sizing and economics resulting from the conventional analysis upon which the final project formulation and recommendation of this report is based. The R&U analysis was undertaken following ER 1105-2-205 for different levee height associated with the final plans considered for the Mayagüez-Hormigueros area. R&U analysis includes not only the expected point estimates of the most important plan formulation variables, but also a range of potential outcomes and their associated probability. Using the Monte Carlo simulation technique, in which multiple iterations are done by selecting and combining inputs from the full range of possible outcomes of the various variables distributions, allows incorporation of uncertainty into the calculation of flood damages for given target stages. These target stages or elevations represent levee overtopping or failure. Uncertainty, variation, or error estimates were developed for the relationships associated with the frequency-discharge, stage-discharge, and stage-damage functions for the existing (without-project) and the with-project conditions. Uncertainty associated with flood protection cost was not included in the analysis. The analysis was undertaken in part with the assistance of staff from the U.S. Army Corps of Engineers' Hydrologic Engineering Center (HEC) and the Institute of Water Resources (IWR) during a workshop held in December 1993 at the Jacksonville District.

2. Methodology and Assumptions. For purpose of this analysis, the Mayagüez-Hormigueros area was subdivided into three reaches based on the hydrological characteristics of the lower flood plain. These reaches coincide with the economic reaches into which the flood plain was subdivided for economic damages analysis. These reaches are: (1) the Guanajibo Homes development, (2) San José development, and (3) Buenaventura, Valle Hermoso, and San Romualdo developments. The floodwall/levee systems for the Guanajibo Homes and San José developments

are related to each other due to the hydraulic characteristics of the area (refer to section 5.F., H&H Appendix). They also share common design conditions. Therefore, the results of the risk based analysis for these areas will be presented and discussed as one reach.

The proposed flood control plan would increase stages about a meter during the one percent chance exceedence frequency event in the Mayagüez-Hormigueros area. Therefore, reduced expected annual damages associated with a particular levee stage were computed from the damages scenarios presented by the existing and the with project conditions stage-frequency curves and corresponding uncertainties.

Following is detailed information on data and associated uncertainty used to evaluate levee sizing for the Mayagüez-Hormigueros study area:

a. Discharge. Based on the basin's characteristics, a single discharge-probability function was developed for the entire Mayagüez-Hormigueros flood plain area. This is because there are no significant tributaries affecting this function between the reaches being considered. This function was used for the existing and the with project conditions. Statistics were computed, in accordance with Bulletin #17B, Guidelines for Determining Flood Flow Frequency, from an adopted curve of computed discharges (HEC-1) and parallel to the regional frequency curve. Refer to sections 2.6. and 5.D.2., of H&H Appendix for frequency discharge curve developed. The function was fit to a Log-Pearson Type III distribution with a logarithmic mean equal to 3.978 and a logarithmic standard deviation of 0.467. A regional skew coefficient of 0 was used. An equivalent period of record of 25 years was used to develop discharge uncertainty.

b. Stages. A HEC-2 model was developed for the evaluation of the existing and with project conditions. The model was calibrated with detailed information collected from floods associated with Hurricane Eloise in September 1975, a one percent chance exceedence frequency event. The hydraulics of the existing conditions was used to develop the stage-discharge relationship to compute the without project expected annual damages for the reaches under consideration. The with project hydraulics was used to compute the with project expected annual damages. Uncertainty for each of the stage-discharge function (with project and without project) for the one percent chance exceedence frequency event was determined from the comparative analysis of three approaches: (1) the values shown in the Minimum Standards Deviation Table provided in EC-1105-2-201; (2) the absolute difference between watermarks from the 1975 flooding event and the profile developed with the HEC-2 model for existing conditions; and (3) one fourth of the stage difference between the upper and lower bounds around the HEC-2 developed profile for existing conditions that resulted from a water surface profile sensitivity analysis (varying "n" value) for the flood plain. The sensitivity analysis results were selected for the computation of the standard deviation of the stage-discharge functions. Standard deviation of stage uncertainty for the one percent chance exceedence frequency event ranges from 0.30 meters in the Buenaventura-Valle Hermoso area to 0.38 meters in the Guanajibo Homes and San José area for the without project conditions, and 0.52 and 0.34 for the with project conditions respectively.

c. Damages. In the case of the economic estimates, uncertainty was determined through a proportional random sample of 73 observations for estimating errors associated with value of structure, value of content, and the first floor elevation of residential structures in the Mayagüez-Hormigueros area. Only residential property was considered because they make up 95 percent of total structures and facilities in the flood plain and account for about 85 percent of the potential damages. The variation underlying these estimates was estimated for each damage reach in the Mayagüez-Hormigueros area to be as follows:

DAMAGE ERROR ESTIMATES FOR RISK ANALYSIS

DEVELOPMENT	STANDARD DEVIATION FOR		
	AVERAGE VALUE OF STRUCTURE PER UNIT	AVERAGE VALUE OF CONTENT PER UNIT	AVERAGE FIRST FLOOR ELEVATION
Guanajibo Homes	\$5,190	\$2,992	0.25
San José	2,033	1,987	0.25
Ramírez de Arellano	13,111	3,033	0.25
Vista Verde	2,000	2,000	0.25
Buenaventura	7,554	3,632	0.24
Valle Hermoso	8,566	2,722	0.24
San Romualdo	6,100	3,900	0.25

On the basis of past experience with FEMA's Detailed Survey Reports for residential structures, a 25 percent error of damage at each stage and a confidence level of 95 percent were assumed for the depth-damage relationship.

d. Costs. Cost estimates including real estate costs and O&M was developed for three stages or levee heights, corresponding to three conventional (50-year, 100-year, and SPF) levels of protection. These cost estimates reflect 1993 price level. No uncertainty was developed for the cost estimates.

3. Procedure. Monte Carlo simulation is used to determine expected annual damages (EAD), with-project damages, benefits, and project reliability by explicitly and jointly incorporating the estimated uncertainties in the various functions. The number of iterations in the simulations was carried for the EAD analysis (sizing of plan) and for the reliability of the plan until the values converge to the input statistics or until no significant change in the expected values were being obtained with additional iterations.

Two risk-based analysis work sheet templates were developed. The first one for economic analysis includes: the depth-damage percentage curve for residential land use; the mean values and standard deviations of value structure, value of contents and first floor elevation at a reference point for the housing structures in each of the developments under consideration; and the rating curve and associated standard error for 15 stage points. For each stage, 2,000 iterations were run to generate the stage-damage curve with uncertainty. This curve served as an input to the second work sheet. This second work sheet includes the

discharge frequency curve with uncertainty and the stage discharge with uncertainty for three stage points for the Guanajibo Homes/San José developments and four stage points for the Buenaventura/Valle Hermoso developments. For each of these stage points, 5,000 iterations were run to generate expected annual damage and benefits.

Project reliability simulations (performance) was undertaken for every stage (target elevation) associated with the floodwall/levee system for each reach under consideration for the 2, 1, 0.4, 0.2 percent chance events. This analysis provides information on percent probability of the levee containing the particular event under consideration. As in the levee sizing process, 5,000 iterations were used to simulate each levee height performance.

4. Results of Risk Based Analysis. Tables 13 and 14 show the sizing and reliability simulation results for selected floodwall/levee elevation for the Guanajibo Homes and San José developments, and for the Valle Hermoso, Buenaventura, and San Romualdo developments flood control levee, while Table 15 summarizes for both the conventional and the risk based analysis the corresponding elevation of the levee, economics, and performance of each plan considered.

The results on the risk based analysis summarized in Table 15 show that the levee elevation of the NED plan for the Guanajibo Homes/San José has a 0.48 percent chance of being overtopped in any given year (208-year) as compared to a 100-year level established from the conventional analysis. The corresponding figures for the NED plan levee elevation of the Valle Hermoso/Buenaventura developments are 0.80 percent and 125 years as compared to the 100-year level established from the conventional analysis. The higher performance resulting from the risk based analysis is in consonance with local (Puerto Rico Planning Board) and Federal (FEMA) guidelines and regulations. On the other hand, the results of the risk based analysis shown in Tables 13, 14, and 15 of the report validate the economics (in terms of optimum size of the levee) of the conventional analysis given level of detail, land use (damages) considered and level of error in cost estimates. In the case of Guanajibo Homes/San José developments the optimum levee size under the R&U analysis and the NED plan under the conventional analysis coincides, while in the case of Valle Hermoso/Buenaventura developments the R&U optimum levee size (9.5 meters) is 0.7 meters lower than the NED plan resulting (10.2 meters) from the conventional analysis. It involves a difference in annual net benefits of only \$43,000, which is small and most likely within the bounds of the data and analysis methods used.

In conclusion, the results from the risk based analysis served to better establish the performance in terms of exceedence probability of the NED plan elements (levee) for the Mayagüez-Hormigueros area as well as for validating the sizing and economics of the plans elements resulting from the conventional analysis.

TABLE 13
RIO GUANAJIBO FEASIBILITY REPORT
RISK ANALYSIS

LEVEE SIZING GUANAJIBO HOMES-SAN JOSE LEVEE AND FLOODWALL						
Top Elevation of Levee (Meters NGVD)	Exceedence ² Probability	True ³ Exceedence Probability	ANNUAL DAMAGES (x \$1,000) ¹			Net Benefits (x \$1,000)
			Without Project	With Project	Reduced	
5.0	0.0058	0.0106	1.138	227.6	910.4	392.9
5.6 ⁴	0.0012	0.0048	1.138	102.0	1,036.0	472.6
6.0	0.0001	0.0006	1.138	7.0	1,131.0	572.4
						517.5
						563.4
						558.6

RELIABILITY OF LEVEE STAGE FOR SELECTED EVENTS¹

FLOODING EVENTS				
Top Elevation of Levee (Meters NGVD)	0.02 (50-Year)	0.01 (100-Year)	.004 (250-Year)	.002 (500-Year)
5.0	85.8	67.3	40.2	24.0
5.6 ⁴	95.9	89.5	75.1	64.2
6.0	99.1	97.4	93.6	89.7

¹Include only residential damages.

²Exceedence probability taken from discharge-frequency curve (HEC-1).

³Exceedence during simulation shows true probability of levee being overtopped a particular year.

⁴Recommended NED levee elevation in report.

⁵Probability of levee containing a particular event.

TABLE 14
RIO GUANAJIBO FEASIBILITY REPORT
RISK ANALYSIS

LEVEE SIZING VALLE HERMOSO AND BUENAVENTURA LEVEE (MAIN LEVEE)									
Top Elevation of Levee at Station 33 + 00 (Meters NGVD)	Exceedence ¹ Probability	True ² Exceedence Probability	ANNUAL DAMAGES (x \$1,000) ⁵			Annual Cost (x \$1,000)	Net Benefits (x \$1,000)		
			Without Protect	With Protect	Reduced				
9.1	0.0100	0.0172	3,196.9	502.2	2,694.7	710.0	1,984.7		
9.5	0.0064	0.0122	3,196.9	349.9	2,847.0	797.2	2,049.8		
10.2 ⁴	0.0027	0.0080	3,196.9	240.3	2,956.6	949.7	2,006.9		
10.8	0.0011	0.0036	3,196.9	129.9	3,067.0	1,120.0	1,947.0		

RELIABILITY OF LEVEE STAGE FOR SELECTED EVENTS ¹					
FLOODING EVENTS					
Top Elevation of Levee at Station 33 + 00 (Meters NGVD)	0.02 (50-Year)	0.01 (100-Year)	.004 (250-Year)	.002 (500-Year)	
9.1	72.2	48.6	23.2	11.7	
9.5	82.6	63.0	35.9	20.9	
10.2 ⁴	92.3	80.8	58.1	40.6	
10.8	96.9	90.8	75.7	61.9	

¹Include only residential damages.

²Exceedence probability taken from discharge-frequency curve (NEC-1).

³Exceedence during simulation shows true probability of levee being overtopped a particular year.

⁴Recommended NED levee elevation in report.

⁵Probability of levee containing a particular event.

TABLE 15
RIO GUANAJIBO FEASIBILITY REPORT

COMPARATIVE SUMMARY RESULTS OF CONVENTIONAL AND RISK BASED ANALYSIS

AREA	CONVENTIONAL ANALYSIS			RISK BASED ANALYSIS LEVEE ELEVATION ALTERNATIVES		
	Plan 1F 50-Year	Plan 2F 100-Year	Plan 3F 250-Year	Plan 1F	Plan 2F	Plan 3F
GUANAJIBO HOMES/SAN JOSE DEVELOPMENTS						
Average Levee Elevation (mts. NGVD)	5.0	5.6	6.0	5.0	5.6	6.0
Annual Cost (in \$1,000)	\$ 393	\$ 473	\$ 572	\$ 393	\$ 473	\$ 572
Annual Benefits (in \$1,000)	\$1,195	\$1,365	\$1,454	\$ 910	\$1,036	\$1,131
Net Benefits (in \$1,000)	\$ 802	\$ 892	\$ 882	\$ 517	\$ 563	\$ 559
Percent Chance or Exceeding Frequency	2.0%	1.0%	0.4%	1.06%	0.48%	0.06%
Project Performance (in years) as determined from the R&U Analysis	94	208	1,666	94	208	1,666
VALLE HERMOSO/BUENAVENTURA DEVELOPMENTS						
Levee Elevation (mts. NGVD) at Station 33 + 00	9.5	10.2	10.8	9.5	10.2	10.8
Annual Cost (in \$1,000)	\$ 797	\$ 950	\$1,120	\$ 797	\$ 950	\$1,120
Annual Benefits (in \$1,000)	\$3,520	\$3,825	\$3,987	\$2,847	\$2,957	\$3,067
Net Benefits (in \$1,000)	\$2,723	\$2,875	\$2,867	\$2,847	\$2,957	\$3,067
Percent Chance or Exceeding Frequency	2.0%	1.0%	0.4%	1.22%	0.80%	0.36%
Project Performance (in years) as determined from R&U Analysis	82	125	277	82	125	277

IX. RECOMMENDED PLAN

A. Description of Components

The recommended plan consists of a combination of the economically justifiable elements of Plan 2F for the Mayagüez-Hormigueros area and Plan 1F-SG for the San Germán area (Plates 6 and 7).

The recommended plan of improvements for the Río Guanajibo basin consists of 6.26 kilometers of a floodwall and levee system along developed areas in the flood plain in the Mayagüez-Hormigueros area to protect it against floods greater than the 1 percent base flood in consonance with FEMA's April 23, 1993, letter to CECW-P. For the San Germán area, the recommended plan includes 1.47 kilometers of channel improvements to Río Guanajibo to provide a 10-year level protection. The plan integrates a significant amount of environmental elements to minimize potential adverse impacts.

The detailed description of the recommended plan for the Mayagüez-Hormigueros area is as follows:

The Guanajibo Homes development including the radio station facilities would be protected by a floodwall/levee structure of selected fill materials with a uniform crest elevation of 5.6 meters (NGVD). The structure would have an average levee height of 4.7 meters and a grass-lined side slope of 1:5. The structure would begin near the south end of the development just upstream from PR Highway 102 and would extend about 1,190 meters north to end at the south end of the Caño Corazones bridge, also at PR Highway 102. A 450 meters section of the structure running from PR Highway 102 adjacent to Caño Corazones up the vicinity of the facilities of the radio station will be a floodwall. A rim ditch would be provided to convey runoff collected behind the levee to a drainage structure where discharges would be made to Caño Corazones.

The San José and Ramírez de Arellano developments would be protected by a floodwall and tieback levee with a total length of 1,570 meters. The purpose of the floodwall is to minimize impacts on valuable wetlands in the area. The San José development would be surrounded by two segments of a floodwall and one diagonal segment of levee that ties into existing high ground west from the development. Top elevation of the floodwall would be set at 5.6 meters (NGVD), while the levee would have average height of 4.3 meters and a grass-lined side slope of 1:5. Crest elevation (NGVD) for the tieback levee would vary from 5.6 meters at transition point with the floodwall to 5.9 meters at tied point with high ground. Proposed floodwall/levee project for the Guanajibo Homes/San José developments is expected to have a 0.48 percent chance of being overtopped in any given year (208-year).

The levee that will provide flood protection to the developed areas of Buenaventura, Valle Hermoso, and San Romualdo would start on the east bank of Río Hondo and continue southeastward for about 1.5 kilometers to the north side of a knoll where a new urban development was built above FEMA's Flood Insurance Rate Map 100-year flood stage just downstream of PR Highway 100. A short section of the levee would connect the east side of the developed area with the PR Highway 100 bridge approach. This segment of the levee has an average levee height of about

4.5 meters with side slopes of 1:4. A tieback levee would be required along the southeast bank of Río Hondo. This tieback levee starts where the levee intersects the east bank of Río Hondo and extends for about 900 meters northeastward to tie into high ground just south of PR Highway 114. Side slopes for the levees would be grass-lined for their entire lengths. The levee would continue upstream PR Highway 100 and extend along the south edge of PR Highway 309 for about 900 meters to the west bank of an unnamed creek. This last segment of the levee would have an average height of 6.2 meters. The plan would include a ramp on PR Highway 114 and two small ramps for accessing farm lands. Proposed levee project for the Valle Hermoso/Buenaventura developments is expected to have a 0.8 percent chance of being overtopped in any given year (125-year).

Urban runoff for the Mayagüez-Hormigueros areas protected by recommended plan would be collected throughout the array of several drainage ditches and corrugated metal culverts located along proposed levee system. The interior drainage improvements were sized to provide minimum facilities in accordance with Engineering regulations. Stages are not increased above natural conditions. The Guanajibo Homes levee would include two 1.5 meters diameters flap gated culverts and drainage ditch to discharge runoff into Caño Majagual. A drainage ditch would drain runoff from San José development towards Quebrada Sábalo. The main levee for the Buenaventura, Valle Hermoso, and San Romualdo communities would include a total of 20 flap-gated culverts distributed between 8 different locations along the structure with diameters ranging from 1.82 to 1.52 meters. These drainage points would be connected through drainage ditches along the levee.

The recommended plan for the Mayagüez-Hormigueros area would require approximately 260 acres: 98 (including 27.6 for mitigation) in simple fee; 160 in easements, and about 2 acres because of severance. The plan would require acquisition of 2 commercial outlets; 3 abandoned commercial structures; 1 demolished burned building, 1 industrial building; 4 residences; 2 abandoned waste water treatment facilities; and a basketball facility. Power lines in the vicinity of PR Highway 14 will also be relocated.

The recommended plan for the Mayagüez-Hormigueros area would involve the acquisition of 27.6 acres of land located between mangroves on the Caño Corazones and the adjacent mangrove wetland east of the Guanajibo Homes development. The area would be scraped down to the elevation of the mangroves on either side of the property. The excess material would be disposed at the borrow area. Mangroves planting and monitoring would be included as part of the mitigation plan.

The recommended plan for the San Germán area consist of 1.5 kilometers of channel improvements. The channel will be gabion lined and will have a bottom width of 65 meters. The degree of protection afforded by the improvements will be only against the 10-year flood. The bridge on Highway 119 will be replaced as part of the improvements. The plan will be complemented with the ALERT System which will provide for relocating families in case of rainfall with potential of resulting in floods exceeding the design flood.

The improvements to San Germán will require the acquisition of a gas station and land easements on 25.4 acres. Overhead utility lines currently along the PR 119 bridge would be temporarily relocated during bridge construction. Channel clean out would be required beneath the PR

360 bridge, under which extends a 24 inch diameter sewer trunkline, supported on concrete foundation piers. This sewer line will need to be relocated prior to construction of replacement bridge.

Attorney's Opinions of Compensability were prepared on the relocations associated with the plans of improvement for the Mayagüez-Hormigueros area and the San Germán area and compensable interests have been established.

The recommended plan is shown on Plates 6 and 7. Typical cross sections of project features and details of flood profiles for the recommended plan of improvements are presented in Appendix A.

B. Summary of Impacts and Economics

A hydraulic analysis of the with-project conditions revealed that the Guanajibo Homes floodwall/levee would increase stages in the San José area in bout 0.4 meters. On the other hand, the San José flood control feature would have an impact of about 0.7 meters on Guanajibo Homes. Same analysis showed that construction of these two floodwall/levee features would increase flood stages in the Buenaventura and Valle Hermoso area. However, construction of this last flood control feature would have no impact on flood stages in the Guanajibo Homes and San José developments (refer to Section 5. F., H&H Appendix, for detailed analysis). Due to this interdependency, all features within the Mayagüez-Hormigueros area are considered as a single project in the recommended plan. However, in the Economic Appendix information on cost, benefits, and benefit to cost ratio is provided separately for each element in the recommended plan. In accordance with above mentioned hydraulic analysis, the San Germán area is definitely separate from the Mayagüez-Hormigueros area. Flooding problems in the San Germán area are mainly due to lack of adequate channel capacity in this river reach. Proposed channel improvements for the San Germán area requires replacement of PR Highway 119 bridge. Bridge replacement by itself would have significant impact on reducing flooding in this area. Therefore, both flood control features are considered non-separable elements.

Tables 16 and 17 summarize, respectively, the cost estimates and economic impacts of the recommended plan for each of the detailed study areas and for the project as a whole. Detailed cost estimates are presented in Appendix C, Design and Cost Estimates, while details on benefits associated with the plans are discussed in Appendix E, Economic Analysis. The cost figures shown in Table 16 differ from those used for evaluation of the final plans (Table 12) and the risk-based analysis (Tables 13 and 14). The cost figures for the recommended plan are MCACES detailed cost estimates as of October 1994 as compared to preliminary more aggregate cost estimates developed in July 1993 for comparing several plans and their components in order to identify the candidate final plan for recommendation. In addition, MCACES cost estimates for the recommended plan includes several modifications from the final plans such as a 450 meters floodwall section of Guanajibo Homes levee adjacent to Caño Corazones, protection of the radio station in the area and detailed analysis for location and size of drainage facilities.

Total first cost of the components of the recommended plan for the Mayagüez-Hormigueros area is \$18.4 million, while annual cost including interest during construction and O&M is \$1.6 million. Implementation of the plan will result in NED of \$3.8 million and a

TABLE 16
RIO GUANAJIBO FEASIBILITY REPORT
COST ESTIMATES OF RECOMMENDED PLAN
(\$1,000 of October of 1994)

D E S C R I P T I O N	MAYAGUEZ HORMIGUEROS AREA	SAN GERMAN AREA	TOTAL PROJECT AREA
Bridges and Roads	\$ 397.0	\$1,486.2	\$ 1,883.2
Levees and Floodwalls	10,258.5	-----	10,258.5
Channel and Canals	721.9	3,592.6	4,314.5
Flood Control in Diversion Structure	-----	122.5	122.5
Utilities	48.0	130.4	178.4
Wildlife Facilities	380.4	0	380.4
TOTAL CONSTRUCTION COST	\$11,805.8	\$5,331.7	\$17,137.5
Lands and Damages	3,103.4	621.6	3,725.0
P.L. 91-646 Assistance	165.6	14.4	180.0
Planning, Engineering, and Design	1,814.0	859.0	2,673.0
Construction Management	1,540.0	885.0	2,425.0
TOTAL FIRST COSTS	\$18,428.8	\$7,711.7	\$26,140.5
Less PL 91-646 Assistance	165.6	14.4	180.0
TOTAL ECONOMIC FIRST COST	\$18,263.2	\$7,697.3	\$25,960.5

TABLE 17
RIO GUANAJIBO FEASIBILITY REPORT
SUMMARY OF ECONOMICS OF RECOMMENDED PLAN
(\$1,000 of October 1994 and i = 7 3/4 for 50-Year)

	MAYAGUEZ-HORMIGUEROS AREA	SAN GERMAN AREA	TOTAL PROJECT AREA
TOTAL ECONOMIC FIRST COST			
Interest during Construction	\$18,263.2	\$7,697.3	\$25,960.5
TOTAL INVESTMENT COST	1,024.5 \$19,287.7	388.1 \$8,085.4	1,412.6 27,373.1
Annual Investment Cost	\$ 1,531.5	\$ 642.0	\$ 2,173.5
Annual Operation and Maintenance	60.0	20.0	80.0
TOTAL ANNUAL COST	\$ 1,591.5	\$ 662.0	\$ 2,253.5
Annual Benefits:			
Inundation Reduction	\$ 5,304.5	\$ 701.2	\$ 6,005.7
Employment	78.0	37.0	115.0
Advance Bridge Replacement	0.0	118.0	118.0
Flood Insurance Cost	5.7	0	5.7
TOTAL ANNUAL BENEFITS	\$ 5,388.2	\$ 856.2	\$ 6,244.4
Net NED Benefits	\$ 3,796.7	\$ 194.2	\$ 3,990.9
BENEFIT-TO-COST RATIO	3.4/1.0	1.3/1.0	2.8/1.0

Note: Figures include contingency costs. Details by code of account are shown in Appendix C. Design and Cost Estimates.

benefit to cost ratio of 3.4/1.0. Total first cost of the San Germán improvement under the recommended plan will be \$7.7 million, while annual cost including interest during construction and O&M is \$662,000. Its implementation would have net NED of \$194,200 and a 1.3/1.0 benefit to cost ratio. Total first cost of the recommended plan for the entire project area is \$26.1 million, net NED are \$4.0 million, and the benefit to cost ratio is 2.8/1.0. The net national economic development benefits would produce directly and indirectly net regional annual income of approximately \$10.5 million and about 250 jobs. Most of these jobs would be associated with the intensification of commercial or industrial facilities and housing in the enhanced study area. About 2,500 families would be protected from flooding along the Río Guanajibo flood plain. There would also be some significant adverse temporary economic impacts associated with disruption of traffic and business as a result of replacement of PR Highway 119 bridge in the middle of a highly urbanized area in San Germán.

The recommended plan would require 285 acres of temporary and/or permanent easements and rights-of-way due to project construction, the relocation and buying out of 15 structures, and the replacement of 1 bridge.

The plan would result in some beneficial and some adverse impacts on the area's environmental cultural resources. The recommended plan includes cleaning and leveling 27.6 acres of land in the flood plain east to the Guanajibo Homes to plant mangroves. Detailed discussion of project impacts to the environmental and cultural resources is presented in the EIS.

Though implementation of the plan would reduce average annual equivalent damages in 92 percent, there would still be about almost half a million dollars of average annual equivalent residual flooding damages.

The recommended plan would not lead to additional potential hazards and/or risks to the life of residents of each project area from floods exceeding the design capacities of the project channels and levees. The ALERT flood warning system described in section IV.A.6. would provide an advanced warning of potential major floods exceeding the design plan for the San Germán area. An advanced warning would permit the Civil Defense the performance of an organized evacuation of residents of the area.

The recommended plan was examined in accordance with Executive Order 11988. The recommended plan is the only practicable flood control management plan for the detailed study area. The implementation of the recommended plan would not enhance vacant lands that could induce future urban expansion on the existing flood plain area.

C. Federal and Non-Federal Cost Sharing of Recommended Plan

The Federal Government would design and prepare detailed plans and construct the project (exclusive of those items specifically required of non-Federal interests) after Congressional authorization and funding, upon signing of a contractual agreement for local cooperation as required by Section 21 of the 1970 Flood Control Act and the 1986 Water Resources Development Act, and upon completion of those items of local cooperation required prior to construction.

The local sponsor would be required to provide all lands, easements, and rights-of-way; alterations and relocations to buildings, bridges and public utilities; to hold and save the Federal Government from damages due to the construction works; and to properly maintain and operate all works after completion of the project, including establishing and enforcing regulations, to assure the flood control project accomplishes its objectives.

Table 18 shows cost sharing of total first cost of the project as established in the Water Resources Development Act of 1986 for the Mayagüez-Hormigueros area, for the San Germán area, and for the entire project area. The non-Federal costs would be those associated with easements, rights-of-way, relocations, bridge replacements or new bridges, operation and maintenance. The sponsor is also required by law to contribute 5 percent in cash of the flood control cost. For the Mayagüez-Hormigueros area the total project cost is estimated at \$18.4 million. The sponsor will contribute \$4.6 million or 25 percent, and the Federal share will be \$13.8 million. The corresponding figures for the San Germán area will be \$2.6 or 34 percent for the non-Federal and \$5.1 million Federal. For the project as a whole, which total cost is \$26.2 million, the non-Federal sponsor will contribute \$7.3 million or 28 percent, while the Federal share will be \$18.9 million.

The application of the ability to pay procedures for determining altered cost shares for qualifying non-Federal sponsors is specified on ER 1165-2-121. The recommended Río Guanajibo flood control project does not meet the condition of the benefit test, and therefore does not qualify for a reduction in the non-Federal share.

D. Financial Plan

During several coordination meetings with the local sponsor, the U.S. Army Corps of Engineers field office has discussed and explained the recommended plan for a flood control project for the areas of Mayagüez-Hormigueros and San Germán. The local sponsor understands its responsibilities for contributing with all lands, easements, and rights-of-ways, relocation of bridges and utilities, and the acquisition of buildings and structures necessary for project implementation. In addition, the sponsor understands the Federal requirement for contributing a minimum of 5 percent cash of the total flood control first cost. Options for financing the local share of the project were also discussed. The local sponsor has expressed its support for the recommended plan and its intent to comply with all requirements as outlined in this report.

The local sponsor intends to finance the local share in the project using the same financial scheme used for the multi-million multipurpose Portugués-Bucaná project currently under construction and the upcoming Río Puerto Nuevo flood control project. Project funding will be obtained by annual appropriations from the Commonwealth Legislature for the capital improvement program for flood control works managed by the Puerto Rico Department of Natural and Environmental Resources. These funds are obtained from the annual selling of about \$350 million of Commonwealth of Puerto Rico bonds which are allocated for infrastructure development. The funds, now being budgeted and programmed by the sponsor, will cover its share of the total first cost for

TABLE 18

RIO GUANAJIBO FEASIBILITY REPORT

RECOMMENDED PLAN
 COST SHARING OF TOTAL FIRST COST
 (\$1,000 of October 1994)

DESCRIPTION	MAYAGUEZ- HORMIGUEROS AREA	SAN GERMAN AREA	ENTIRE PROJECT AREA
TOTAL FIRST COST	\$18,428.8	\$7,711.7	\$26,140.5
NON-FEDERAL COST			
Lands and Damages	3,269.0	636.0	\$3,905.0
Relocations			
Bridges and Roads	397.0	1,486.2	1,883.2
Utilities	48.0	130.4	178.4
5% Flood Control	921.4	385.6	1,307.0
TOTAL NON-FEDERAL COST	\$ 4,635.4	\$2,638.2	\$7,273.6
TOTAL FEDERAL COST	\$13,793.4	\$5,073.5	\$18,866.9

construction of the project in accordance with this report and latest PMP. It is reasonable to expect that ample funds will be available to satisfy the non-Federal sponsor financial obligations for the project.

The above financial plan is similar to the ones that have supported recently authorized flood control projects in Puerto Rico such as Río Puerto Nuevo and Río de la Plata.

E. Coordination

The study was developed and worked out in close coordination with the Puerto Rico Department of Natural Resources, the local sponsor; the Puerto Rico Planning Board; the State Historic Preservation Officer; the municipalities of Mayagüez, Hormigueros, and San Germán; the U. S. Fish and Wildlife Service; the U. S. Geological Survey; and the Environmental Protection Agency.

The local sponsor has read and concurs with the findings of the report and has provided (will provide) a Letter of Intent supporting the report's conclusions and recommendations. Letter of Intent is included in Appendix D, Coordination.

The Draft Local Cost Sharing Agreement was discussed with the local sponsor, and they generally understand and concur with it.

The local sponsor, the DNER, will obtain and provide its share of total first cost for construction of project through annual appropriations from the local legislature.

F. Steps to Plan Implementation

Submission of this report by the District Engineer constitutes the first step in a chain of events that must take place before a flood control project can become a reality. It may be modified at any stage of review, and only if it successfully passes each stage will it ultimately be constructed. These events are:

1. Review of the feasibility report and the environmental impact statement by higher Corps of Engineers authorities, including the South Atlantic Division, the Washington Level Review Center, and the Office of the Chief of Engineers.

2. At the request of the Chief of Engineers, formal review by the Governor of the Commonwealth of Puerto Rico.

3. Comments by other interested Federal agencies at the request of the Chief of Engineers.

4. Filing of the final Environmental Impact Statement with the Environmental Protection Agency by the Chief of Engineers.

5. Submission of the feasibility report and EIS to the Assistant Secretary of the Army for Civil Works for review and approval.

6. Review and comment by the Office of Management and Budget regarding the relationship of the project to the program of the President.

7. Submission of the feasibility report and EIS by the Secretary of the Army to the United States Congress.

8. Consideration of the feasibility report by the United States Congress and authorization in a Water Resources Development Act.

9. Inclusion in the President's budget, when appropriate, of funds for Planning, Engineering, and Design (PED) and construction of the authorized project by the Chief of Engineers.

10. Appropriation of the necessary funds by the United States Congress.

11. Fulfillment of the required measures of local cooperation including cost sharing and lands, easements, rights-of-way, and relocations.

12. Completion of the necessary surveys and investigations, preparation of plans, specifications, and an estimate of the construction cost by the District Engineer and acquisition of required permits followed by an invitation for bids and awarding of the construction contracts.

X. CONCLUSIONS

The Río Guanajibo Feasibility Report shows that flooding is a major problem threatening the life, property, and economic development of the residents of the Mayagüez-Hormigueros areas and the town of San Germán, Puerto Rico. The report shows that it is economically justified and necessary to develop and construct a flood control project for this area.

The recommended plan of improvements for the Río Guanajibo basin consists of 6.26 kilometers of a floodwall and levee system along the south part of the Mayagüez-Hormigueros area to protect it against floods greater than the 1 percent or 100-year base flood (208-year flood in the case of Guanajibo Homes/San José developments and 125-year flood in the case of Valle Hermoso/Buenaventura developments), and 1.47 kilometers of channel improvements to Río Guanajibo in the San Germán area to provide 10-year level protection. The plan integrates a significant amount of environmental elements to minimize potential adverse impacts. Some 2,500 families currently living in the flood plain would be protected from the overflow of Río Guanajibo. Total first cost of the recommended plan is \$26,140,500. Net National Economic Benefits are in the order of \$3,990,900 and the benefit to cost ratio is 2.8/1.0. The recommended plan is the National Economic Development Plan. The Federal contribution for the implementation of the plan would be \$18,866,900, while the non-Federal would be \$7,273,600 which represents 28 percent of the total project cost.

I have given consideration to all significant aspects in the overall public interest, including engineering feasibility, economic, social, and environmental effects. The recommended plan described in the report provides the optimum solution for flood protection along the Río Guanajibo and its main tributaries within the framework of the formulation concepts.

XI. RECOMMENDATIONS

I recommend that the plan of improvements for Río Guanajibo described in Chapter IX of this report be authorized for implementation as a Federal project, with such modifications as advisable at the discretion of the Chief of Engineers, for a total first cost to the United States estimated at \$18,866,900 and a benefit to cost ratio of 2.8 to 1.0 provided that, except as otherwise stated in these recommendations, the exact amount of non-Federal contributions shall be determined by the Chief of Engineers following policies satisfactory to the President and the United States Congress prior to project implementation, in accordance with the following requirements to which non-Federal interests must agree prior to implementation:

a. Provide a minimum of 25 percent, but not to exceed 50 percent, of total project costs assigned to flood control, as further specified below:

(1) Provide, during construction a cash contribution equal to five percent of total structural project costs assigned to flood control;

(2) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;

(3) Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project;

(4) Provide during construction any additional amounts as are necessary to make its total contribution equal to 25 percent of total project costs assigned to flood control;

b. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, at no cost to the Government, in accordance with applicable Federal and Commonwealth laws and any specific directions prescribed by the Government;

c. Grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project;

d. Hold and save the Government free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors;

e. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs;

f. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Federal Government determines to be subject to the Navigation Servitude without prior specific written direction by the Federal Government;

g. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project;

h. To the maximum extent practicable, operate, maintain, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA;

i. Participate in and comply with applicable Federal flood plain management and flood insurance programs;

j. Prevent future encroachments on project lands, easements, and rights-of-way which might interfere with the proper functioning of the project;

k. Not less than once each year, inform affected interests of the limitations of the protection afforded by the project;

l. Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

m. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17) and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements,

and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

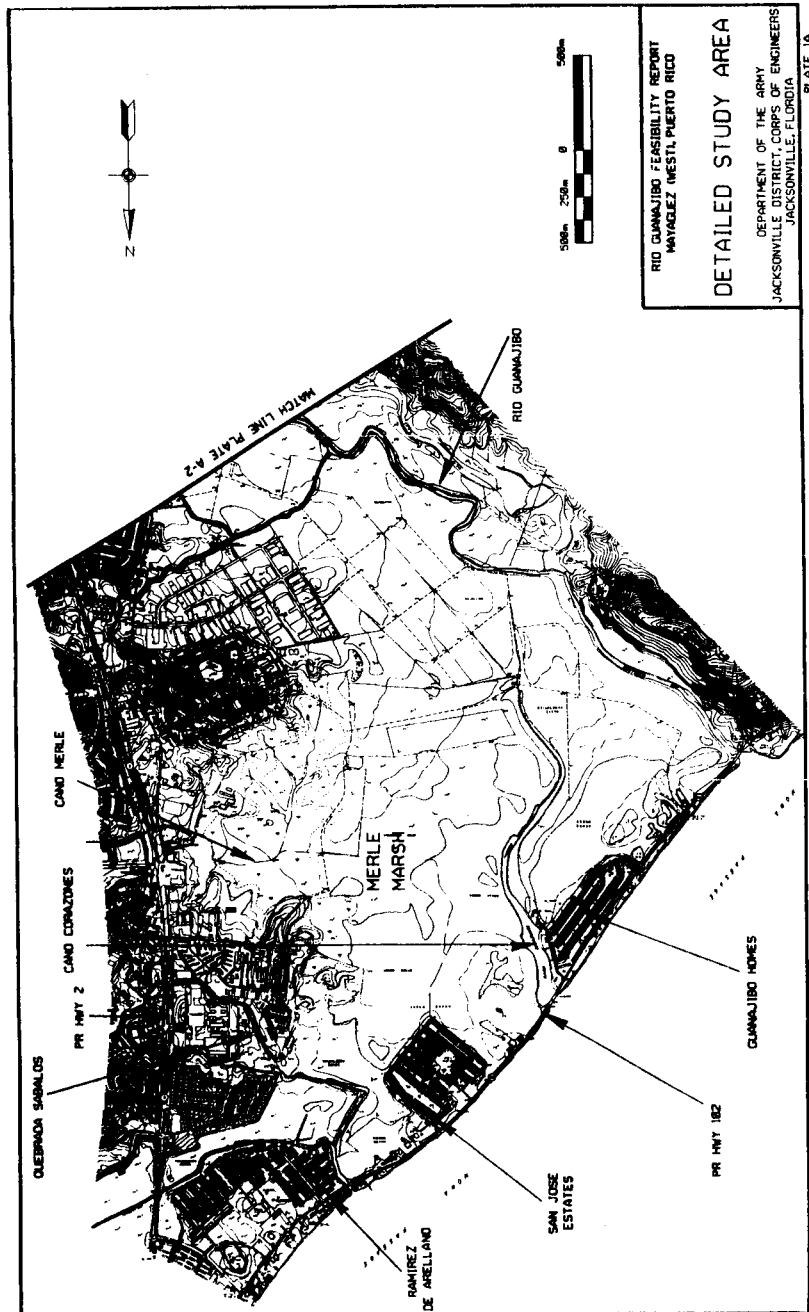
n. Comply with all applicable Federal and Commonwealth laws and regulations, including, but not limited to, Section 601 of Title VI of the Civil Rights Act of 1964, Public Law 88-352 (42 USC 2000D), and Department of Defense Directive 5500.II issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"

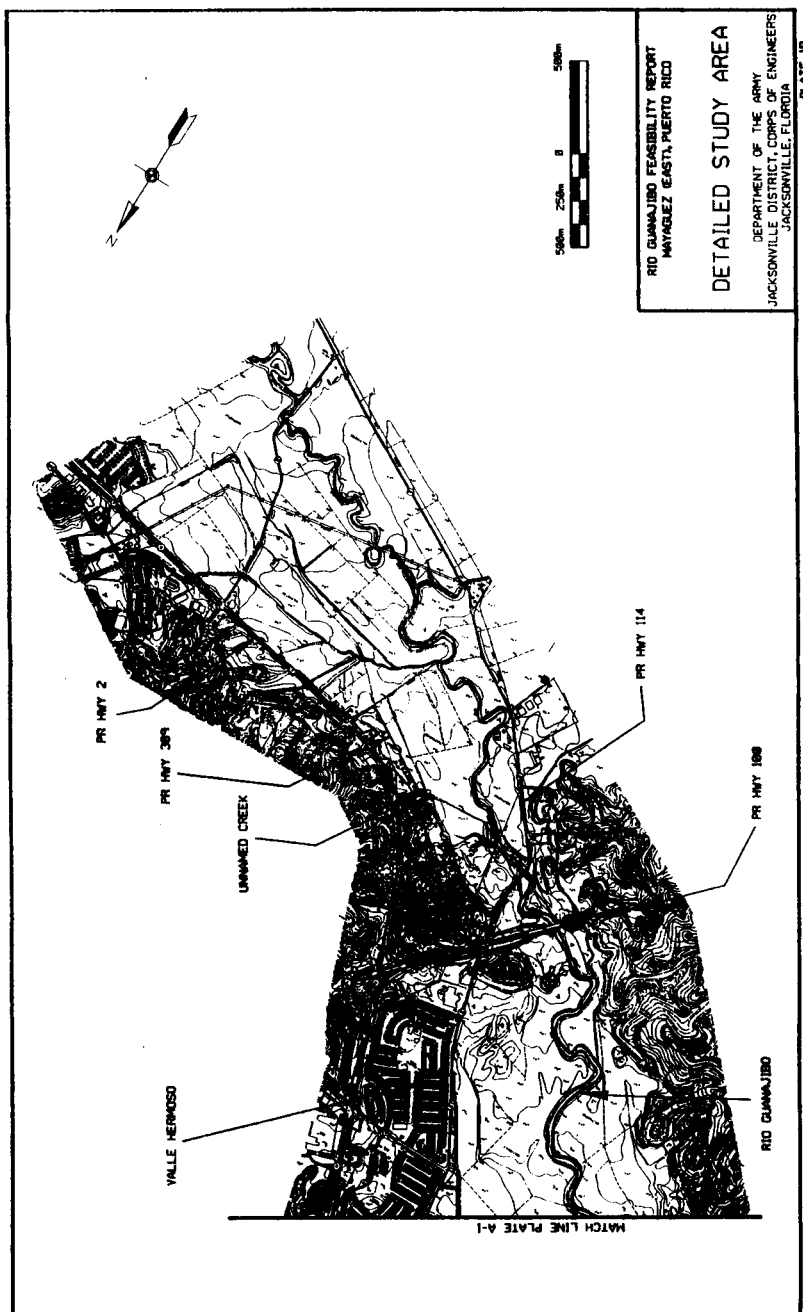
o. Provide 25 percent of that portion of total historic preservation mitigation and data recovery costs attributable to flood control that are in excess of one percent of the total amount authorized to be appropriated for flood control.

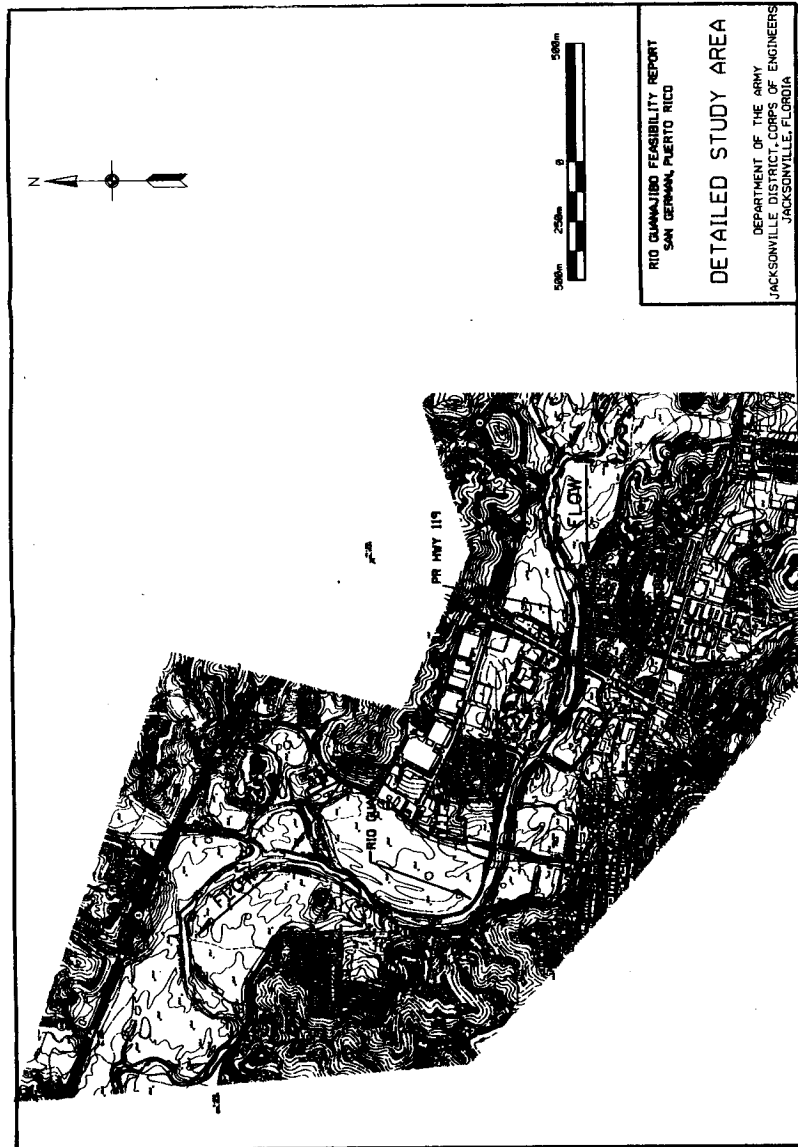
The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the United States Congress as proposals for authorization and/or implementation funding.

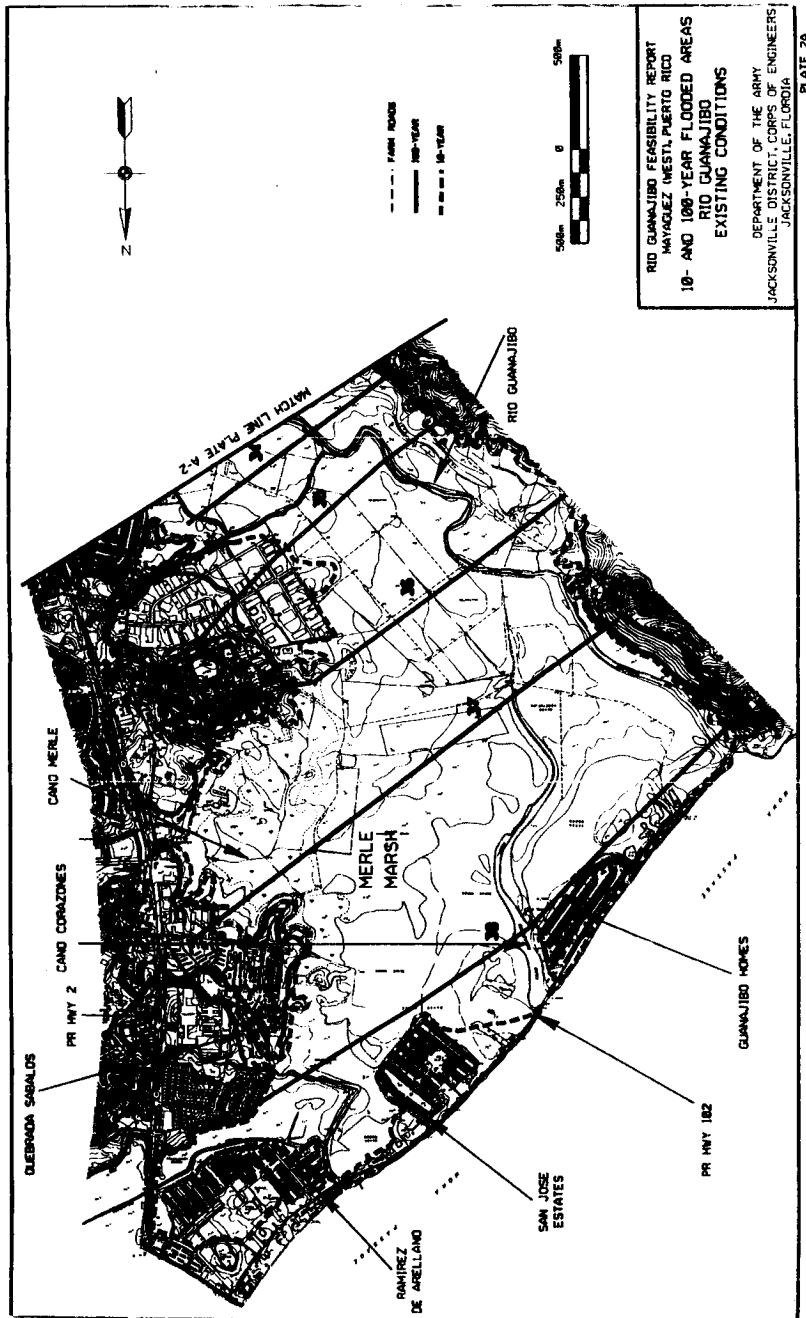


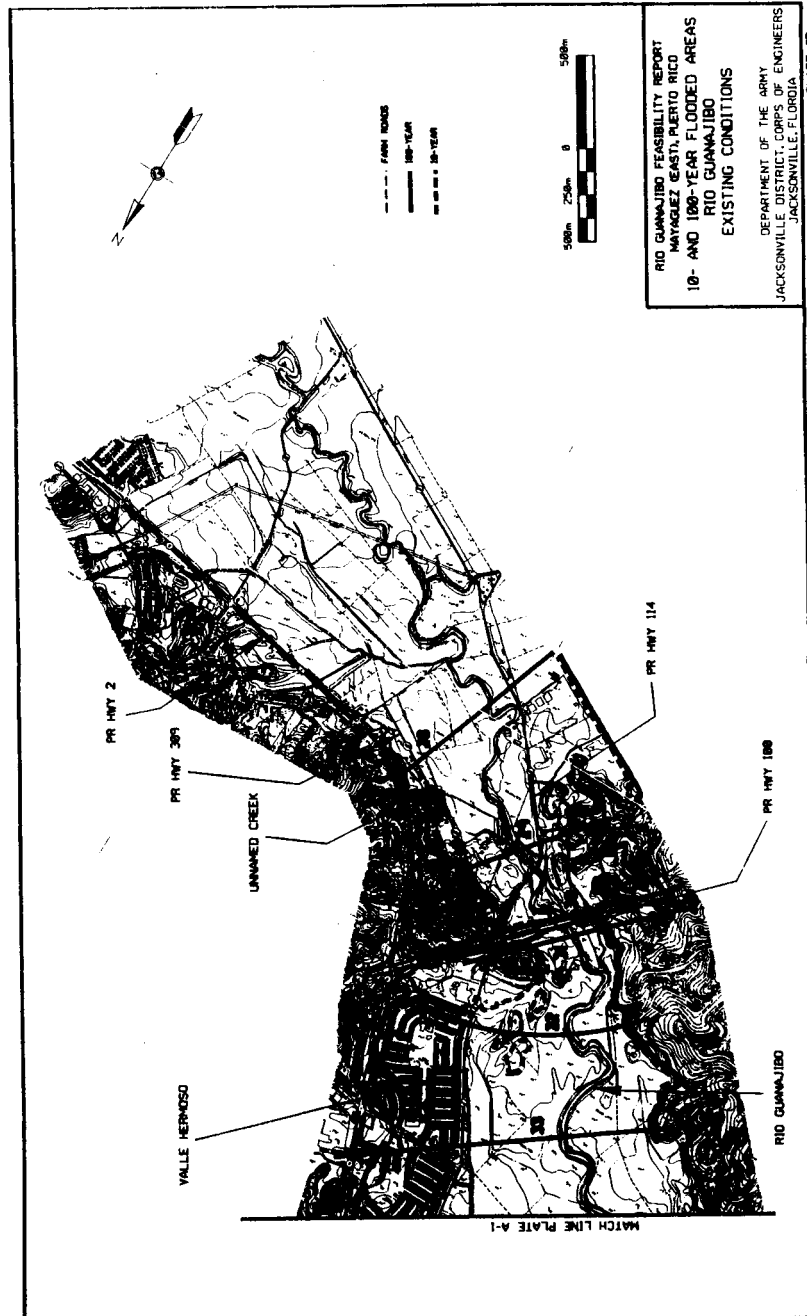
TERRY D. RICE
Colonel, Corps of Engineers
Commanding

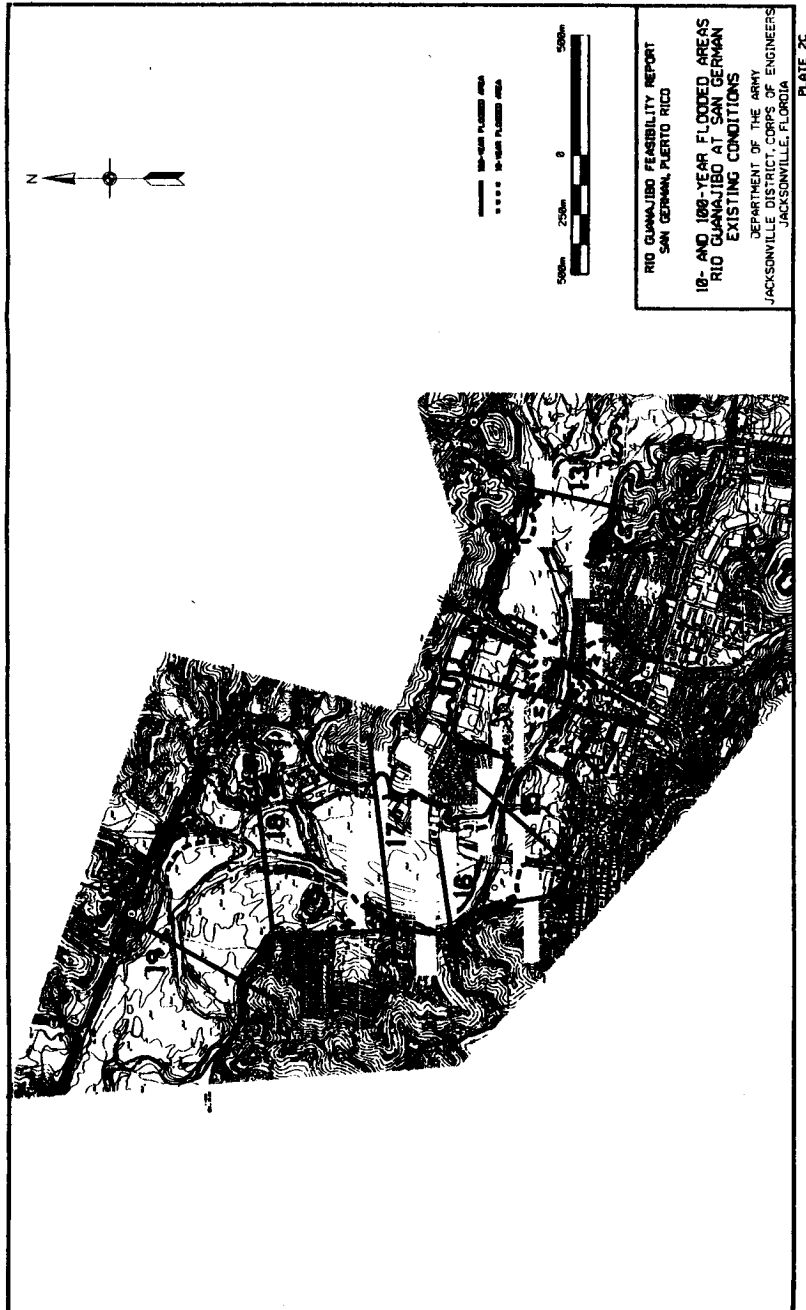


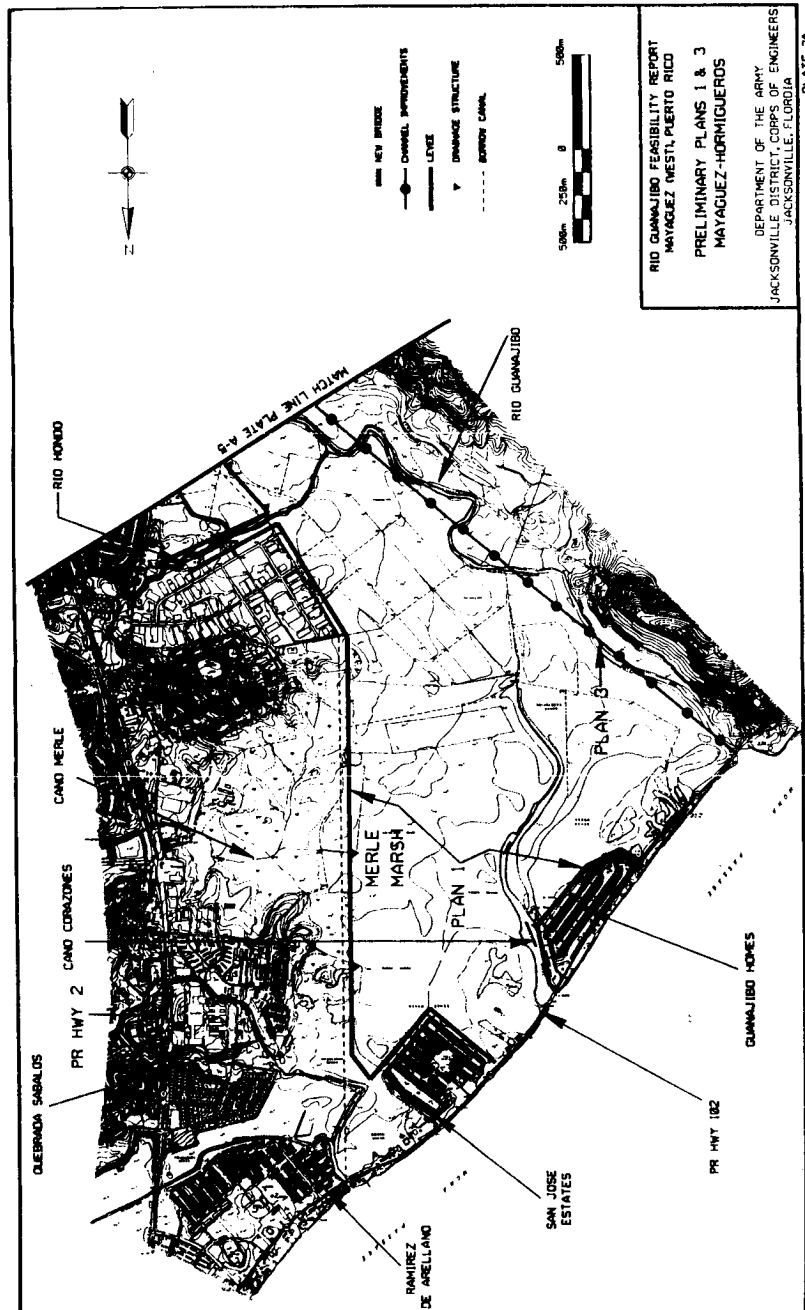


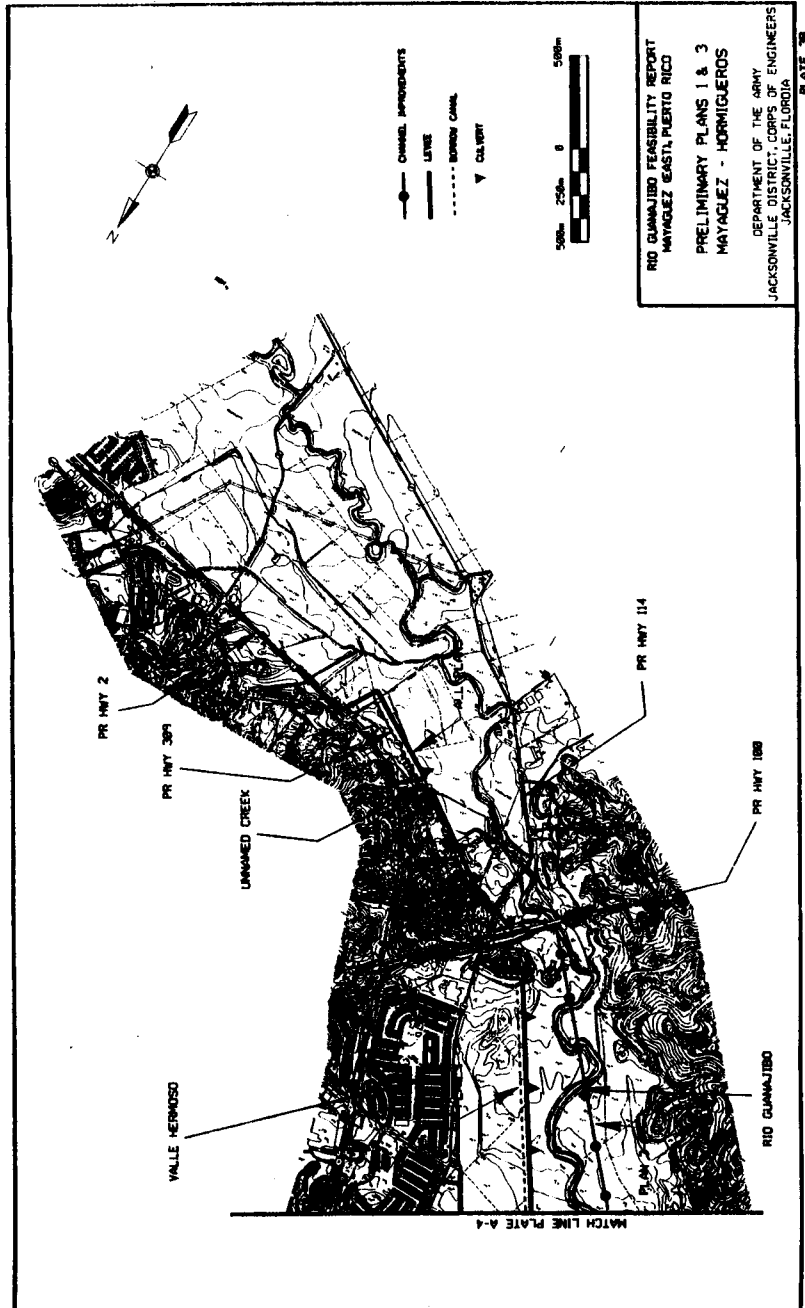


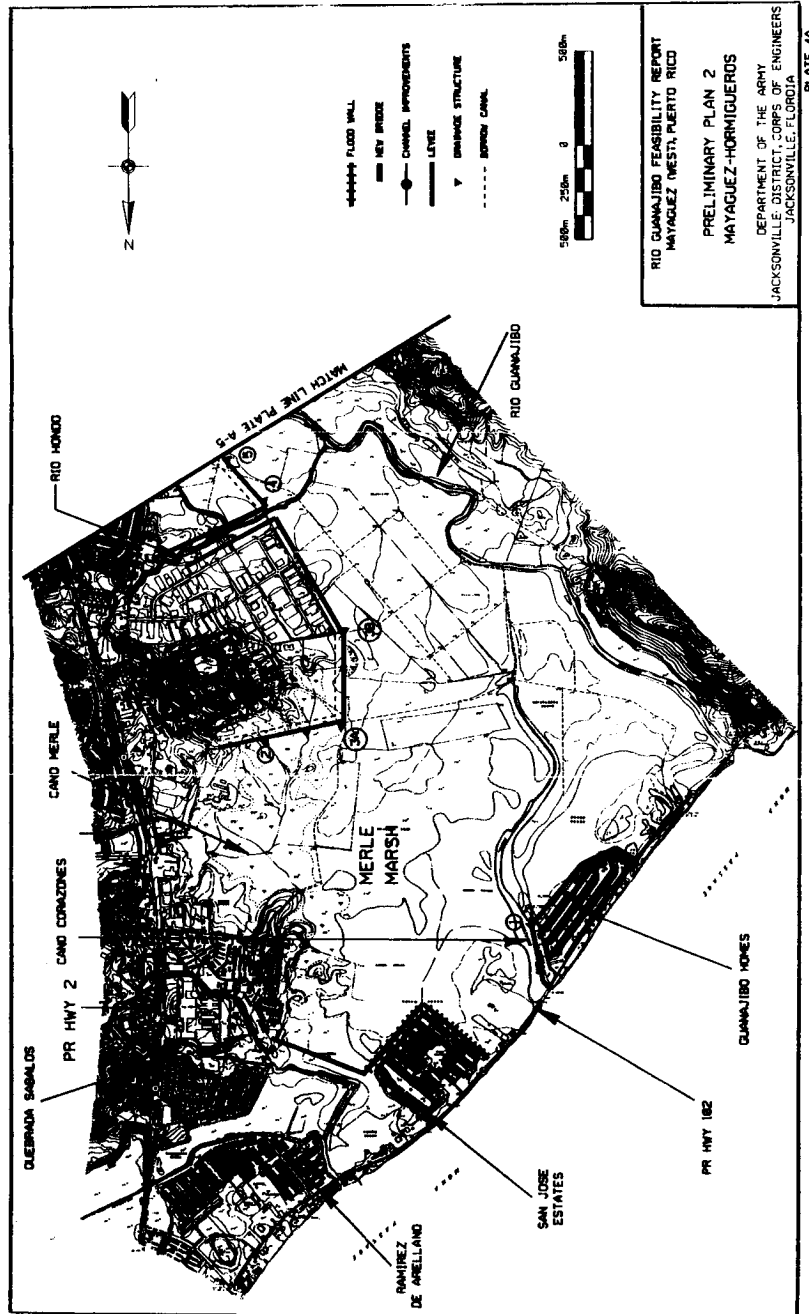


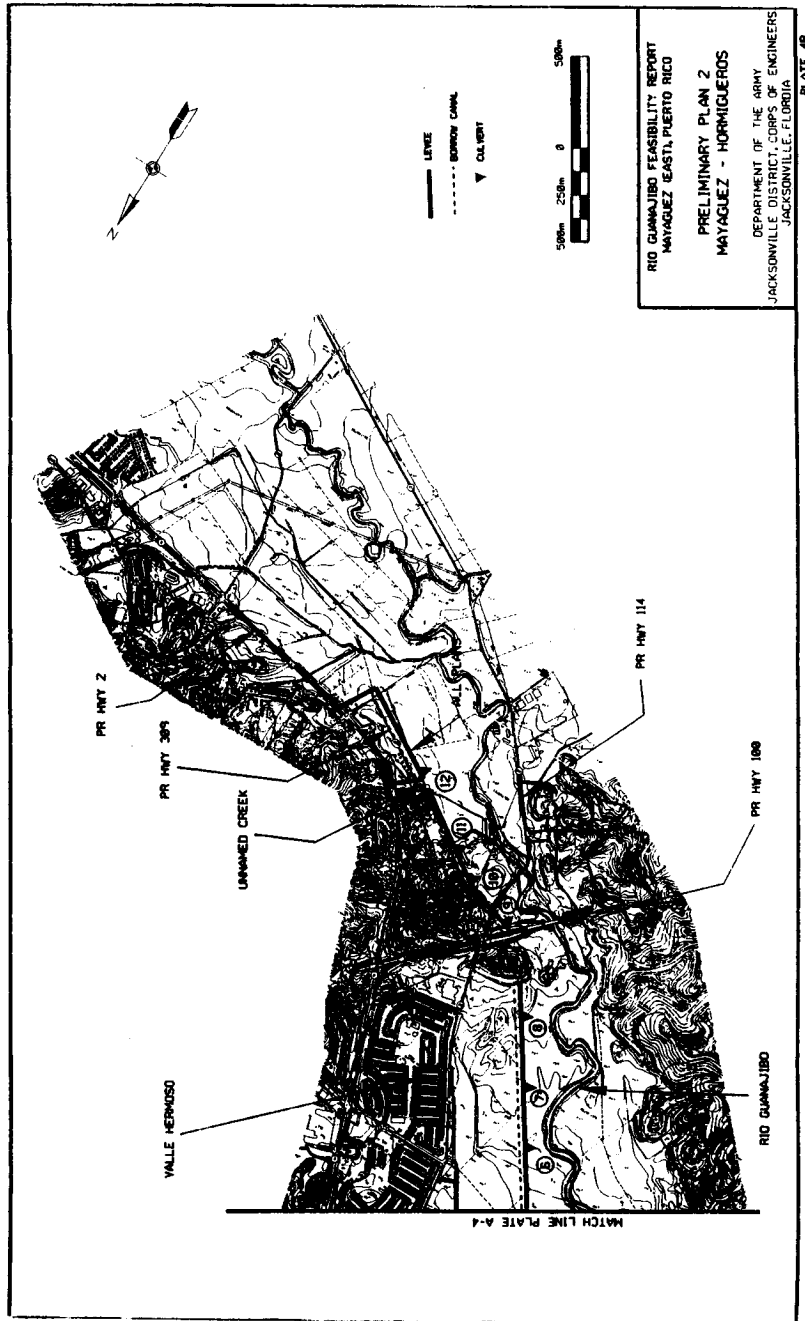


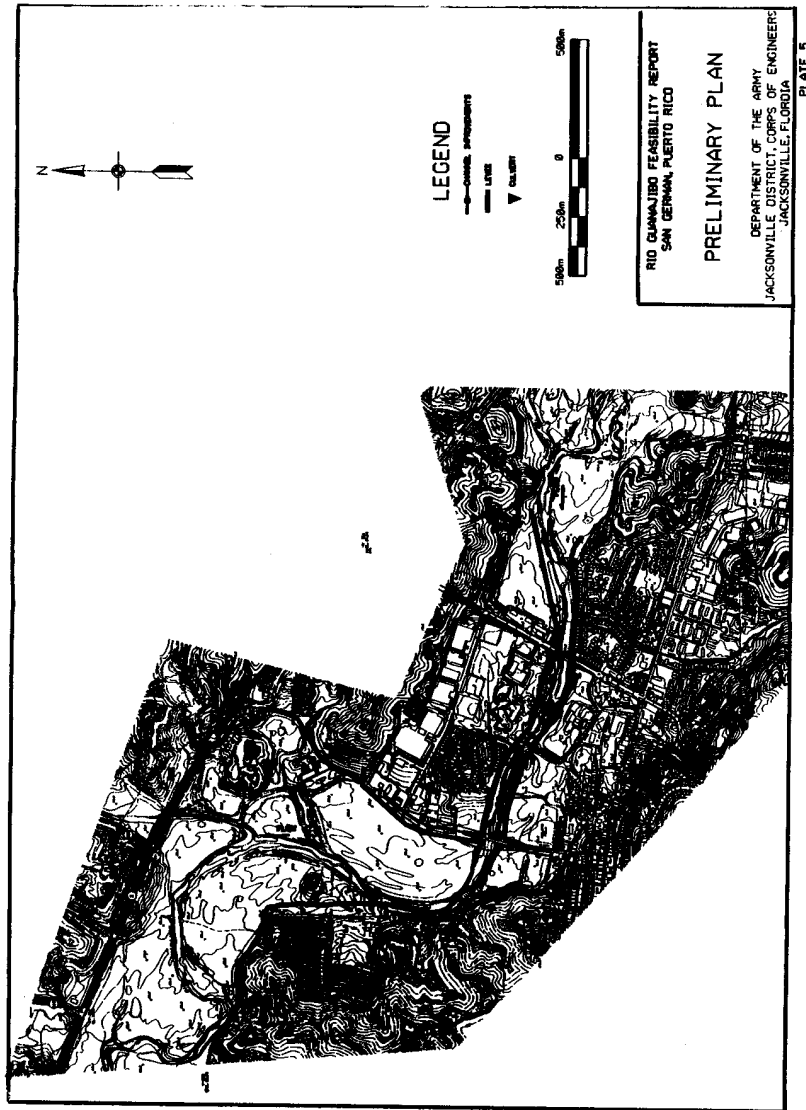


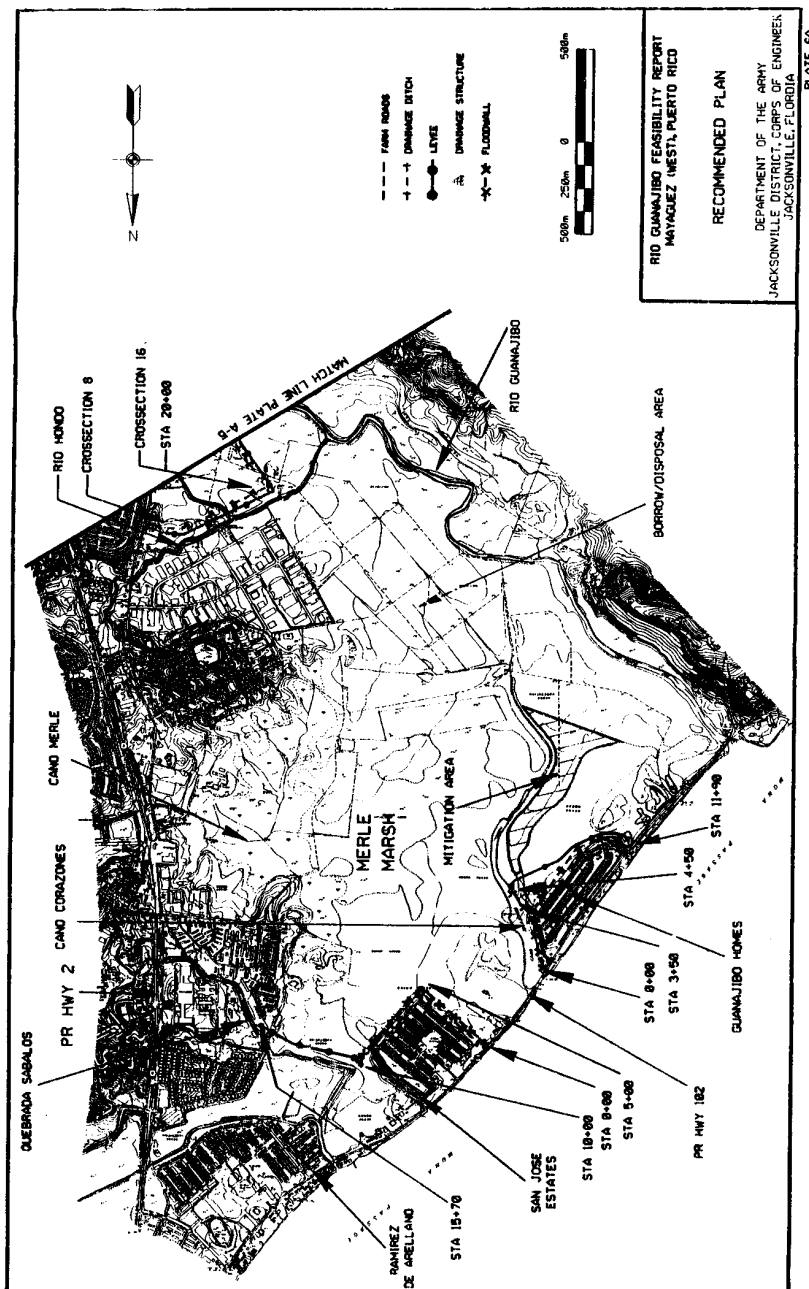


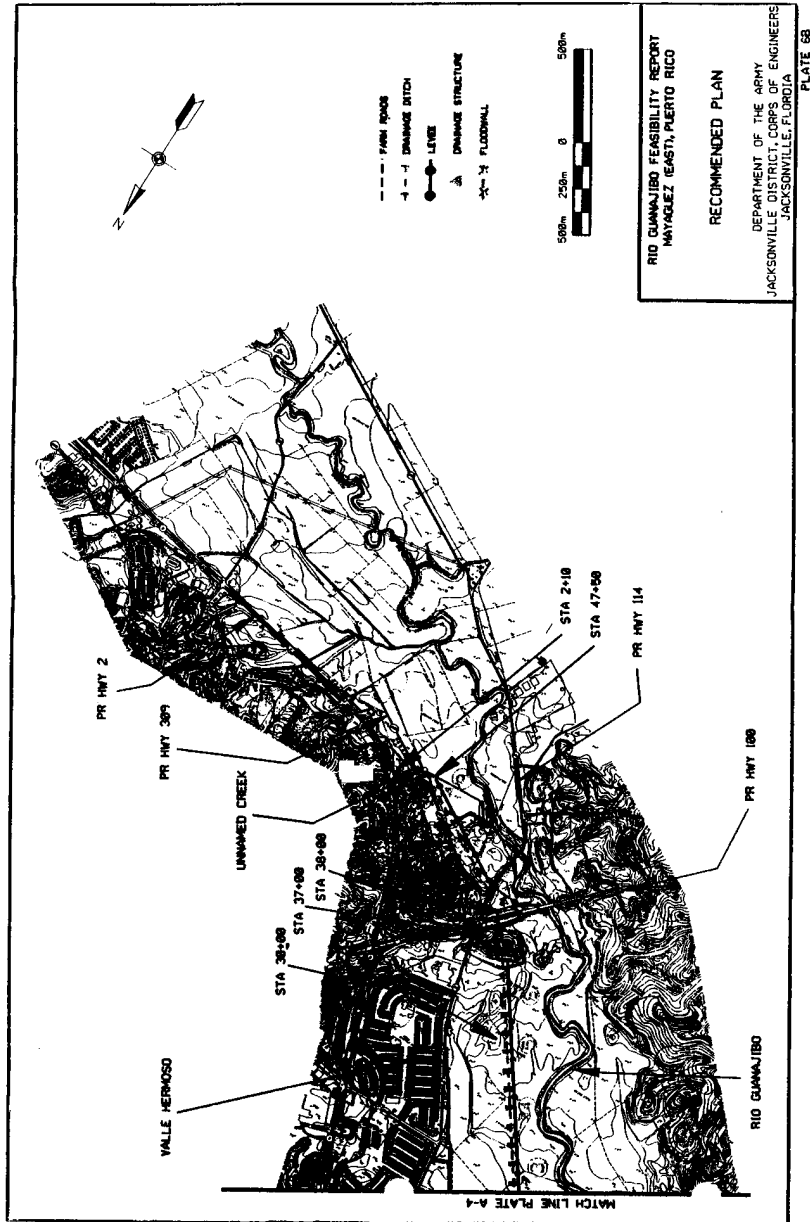


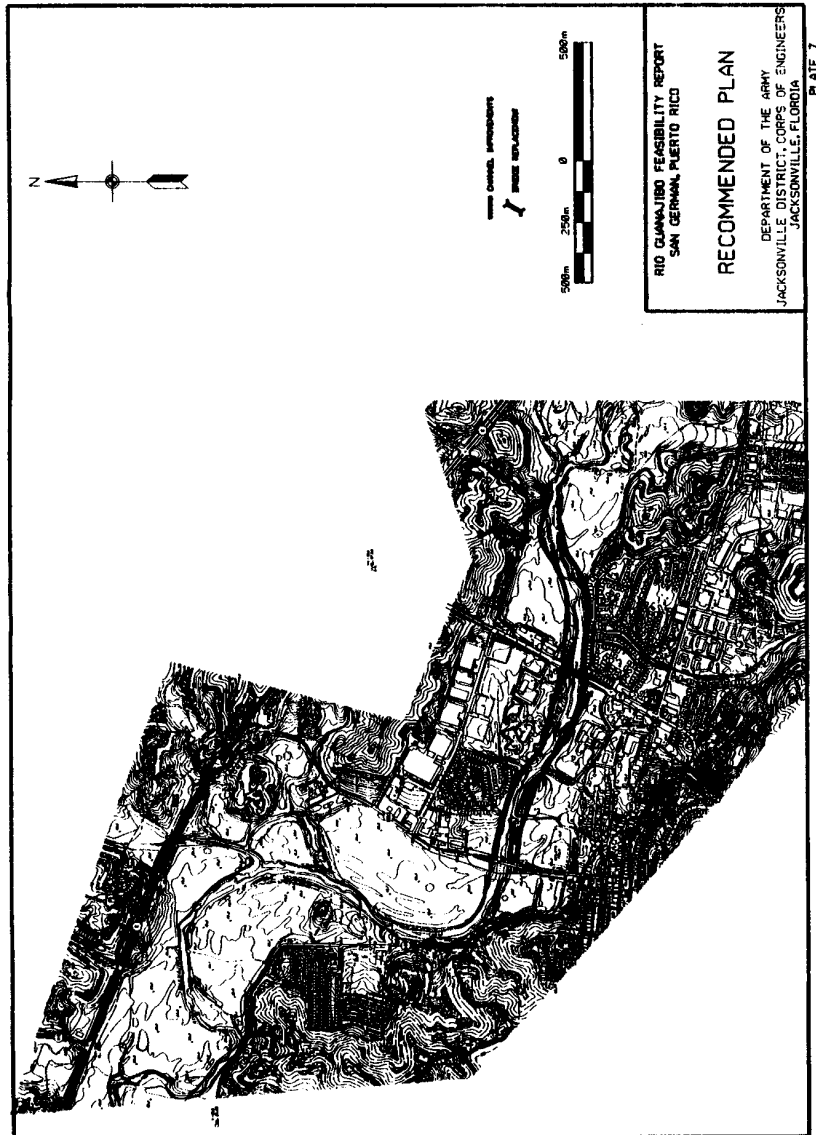












RECOMMENDATION OF THE DIVISION ENGINEER

[First Endorsement]


CESAD-PD-P (CESAJ-PD-PB/20 Sep 94) (10-1-7a)
SUBJECT: Rio Guanajibo, Puerto Rico, Final Feasibility Report
and Environmental Impact Statement

Commander, South Atlantic Division, U.S. Army Corps of Engineers,
Room 313, 77 Forsyth Street, SW., Atlanta, Georgia 30335-6801
30 SEP 1994:

FOR DIRECTOR, WASHINGTON LEVEL REVIEW CENTER (WLRC),
KINGMAN BUILDING, 7701 TELEGRAPH ROAD, ALEXANDRIA,
VIRGINIA 22310-3861

I concur in the recommendation of the District Engineer in the
provision of flood damage reduction measures for the Rio
Guanajibo area of Puerto Rico.

Encl


RALPH V. LOCURCIO
Brigadier General, USA
Commanding

FINAL ENVIRONMENTAL IMPACT STATEMENT

Río Guanajibo Flood Protection Project, Mayaguez and San German, Puerto Rico

Responsible Office: US Army Corps of Engineers, Jacksonville District.

ABSTRACT: The selected plan would provide substantial flood protection to Mayaguez and a minor protection to San German, Puerto Rico. In Mayaguez a levee would be constructed to provide a 100-year level of flood protection. In San German the river channel would be improved to provide a 10-year level of protection. No significant resources would be affected. Important resources identified within the Mayaguez study area include wetlands, residential housing, numerous cultural resources, recreational facilities, prime farmland and commercial properties. The construction of Mayaguez levees would eliminate 27.6 acres of mangrove wetlands. These impacts would be offset by the restoration of a 27.6 acres of mangrove wetlands. There would be an unavoidable loss of 97.9 acres of Prime Farmland from the construction of levees and the excavation of material from the floodplain for construction material in Mayaguez.

SEND YOUR COMMENTS TO THE DISTRICT
ENGINEER WITHIN 30 DAYS OF PUBLICATION
OF THE FINAL EIS IN THE FEDERAL
REGISTER

If you would like further information on this
statement, please contact:
Mr. William J. Fonferek
CESAJ-PD-ES
Jacksonville District
US Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida
32232-0019
Telephone: (904) 232-2803

NOTE: Information, displays, maps, etc., discussed in the Río Guanajibo Flood Protection Study are incorporated by reference in the FEIS.

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EXHIBIT V	SELECTED MITIGATION PLAN
EXHIBIT VI	FISH AND WILDLIFE COORDINATION ACT REPORT
EXHIBIT VII	COORDINATION
EXHIBIT VIII	COMPLIANCE WITH ENVIRONMENTAL LAWS AND REGULATIONS

1.0. PURPOSE OF AND NEED FOR ACTION.

1.1. INTRODUCTION. The Jacksonville District, U.S. Army Corps of Engineers, has studied flooding in the Río Guanajibo River basin in the vicinity of Mayagüez and San Germán, Puerto Rico. Storm events in the Río Guanajibo basin had caused flood damages to residential, industrial and agricultural resources in these areas. The Governor of Puerto Rico requested assistance to alleviate these damages. A Reconnaissance Report was completed in September 1980 indicating that feasible and economic alternatives were available and further, more detailed studies were in order. The local city governments and the Puerto Rico Department of Natural Resources have expressed interest in this project, with the Department of Natural Resources acting as the local sponsor for this project.

1.2. AUTHORITY. The Río Guanajibo Flood Control Study was authorized in accordance with Section 204 of the Flood Control Act of 1970. This General Investigation Study is being conducted as the result of a Congressional resolution from the Committee on Public Works and Transportation of the House of Representatives dated September 23, 1982.

1.3. DECISION TO BE MADE. The decision to be made is whether or not feasible measures would be available to alleviate flood damages in the study area and which measures when considering all relevant issues including environment, would be the most suitable.

1.4. RELEVANT ISSUES. The following issues have been determined to be relevant to the decision:

- a. Impacts on prime farmland
- b. Impacts to water quality
- c. Hazardous, toxic and radiological waste
- d. Flood damage
- e. Noise impacts
- f. Impacts on mangroves
- g. Impacts on emergent wetlands
- h. Endangered species

- i. Impacts on *Pterocarpus* species
- j. Impacts to cultural resources
- k. Impacts on aesthetics
- l. Impacts on recreation
- m. Impacts on economics

1.5. PERMITS REQUIRED. Water quality certification and concurrence in the Coastal Zone Management Consistency Determination would be required from the Commonwealth of Puerto Rico. A National Pollutant Discharge Elimination System permit would be required from the Environmental Protection Agency for construction activities covering 5 acres or greater.

1.6. METHODOLOGY. An interdisciplinary team used a systematic approach to analyze the affected area, to estimate the environmental effects, and to write the environmental impact assessment. This included literature searches, coordination with agencies and private groups having expertise in particular areas, and field investigations.

1.7. DOCUMENT ORGANIZATION. The Draft Environmental Impact Statement (DEIS) is organized into 10 parts:

- a. Table of Contents
- b. Need and Purpose of the Study
- c. Alternatives
- d. Affected Environment
- e. Environmental Consequences
- f. List of Preparers
- g. Consultation with Others
- h. Index
- i. References
- j. Exhibits

2.0. ALTERNATIVES INCLUDING THE PROPOSED ACTION.

2.1. INTRODUCTION. This section is based on concerns for resources and impacts on resources expressed Section 3.0, The Affected Environment, and Section 4.0, The Environmental Consequences. The key to this section is the alternative comparison chart, Figure 2.1, page 5. This section has five parts:

- a. A description of the process used to formulate alternatives.
- b. A description of alternatives that were considered but were eliminated from detailed consideration.
- c. A description of each alternative.
- d. The identification of the preferred alternative.
- e. A comparison of the alternatives.

2.2. HISTORY OF ALTERNATIVE FORMULATION. During the reconnaissance phase planning study, four nonstructural measures and two structural measures were identified to fully or partially address planning objectives. The nonstructural measures considered are flood plain management, flood insurance, temporary and permanent flood plain evacuation, and channel maintenance. Structural measures considered include channel improvements, floodwalls, and levees.

2.2.1. Nonstructural measures.

a. Puerto Rico Planning Board (PRPB) Regulation 13. The most important and relevant nonstructural measure to regulate development in the flood plain is the PRPB Regulation 13. This regulation, which predates Federal Emergency Management Agency (FEMA) flood plain regulations and which in 1987 was revised to make it consistent with FEMA, regulates all new developments and expansion of, or improvements to, existing developments in flood prone areas. For a developer to receive a construction permit in a flood prone area he must establish, through a hydrologic and hydraulic study that his project is above the 100-year flood event or that it will not raise water stages in the vicinity by more than 0.3 meter. Flood plain management regulations are assumed to be in effect under all plans. Flood plain management, however, will have very limited effect in reducing potential flood damages to existing developments.

b. Flood insurance program. The National Flood Insurance Program (NFIP) is administered by the Federal Flood Insurance Administration (FIA), which is part of the FEMA. The PRPB serves as the local coordinating agency for the NFIP in Puerto Rico. Puerto Rico entered the Emergency Flood Insurance Program (EFIP) in 1972 and entered the NFIP in 1978. For purposes of the Flood Insurance Program, Puerto Rico is

considered a single community. Flood insurance would not reduce or eliminate the flooding problem but it would serve to reimburse property owners for losses incurred. The measure, however, seems to have been of very limited acceptance in Puerto Rico because due to the frequent and significant flood damages, insurance premiums tend to be high. However, participation rate is expected to increase because the insurance is an important requisite for any economic transaction that would relate to Federal funds.

c. Temporary and permanent flood plain evacuation. Temporary evacuation of persons and personal property from flood prone areas could be accomplished when a flood threat exists. Temporary evacuation can be very effective when operated in conjunction with a reliable flood warning system and where mobile, damageable objects are a significant portion of personal property. The ALERT system described in Section IV.A.6. of the main report is currently in operation for the Río Guanajibo basin. The system would work in conjunction with an evacuation plan to nonfloodable areas. This measure would contribute to minimize the threat to the lives of residents of the study area. Permanent evacuation of the flood plain areas could be used to reduce flood damage potential. Such a measure involves land purchase, physical removal of buildings and infrastructure, and relocation of population. Lands acquired in this manner could be used for parks or other purposes that would not interfere with flood flows or receive material damage from floods. As part of the reconnaissance study, the permanent relocation of Guanajibo Homes, in the lower valley, was considered in the plan formulation. However, the permanent relocation of 272 housing units with all the communal facilities and 12 commercial and industrial outlets within a highly urbanized area of a major city is to a large extent impractical and would have very little acceptance. Therefore, permanent evacuation was not considered any further.

d. Channel maintenance program. This measure primarily consists of removal of trash, debris, and sediments from the existing stream channel. Though minimal, this measure contributes to all objectives, especially for high frequency floods. This should be a recurring activity every two years.

2.2.2. Structural measures

a. Channel improvements. Since this is very effective at reducing flood damages, this type of measure was considered for the Mayagüez-Hormigueros and for the San Germán area. However, the use of concrete lining in a environmentally sensitive area, like the lower valley, represents a significant adverse impact beyond economical considerations. Therefore, concrete channels in the lower valley were not considered.

b. Floodwalls and levees. These measures preclude floodwater from entering flood prone areas. Since they have proved to be very effective in areas where there is enough open space to accommodate them, without impacting significantly areas out of the protective measure, these measures were considered for both detailed study areas. Floodwalls, although more expensive, have less land requirements than levees and,

therefore, impacts on wetlands are a necessary part of flood protection at certain sites in Mayagüez.

2.3. ELIMINATED ALTERNATIVES. All nonstructural methods of flood damage prevention were eliminated from detailed consideration during the reconnaissance phase of the study for reasons discussed in Section 2.21.

2.4. DESCRIPTION OF ALTERNATIVES. Preliminary flood control plans have been developed separately for the Mayagüez-Hormigueros area and the San Germán area. In the case of the Mayagüez-Hormigueros area, three plans, each protecting against the 100-year flood, were examined. The plans combine floodwalls and levees along the southern fringe of existing developed areas, channel improvements along several of the streams and canals in the area, and improvements to the flood plain conveyance in selected areas. For the San Germán area, four levees and channel improvements plans are analyzed for various degrees of protection.

2.4.1. Mayagüez-Hormigueros Area

(1) **Plan 1.** The plan consists of a levee and floodwall system designed to provide 100-year flood protection.

(2) **Plan 2.** This plan consists of a levee and floodwall system designed to provide 100-year flood protection similar to plan 1 but with a variation downstream from the Río Hondo intersection.

(3) **Plan 3.** This plan consists of channel improvements for Río Guanajibo, a levee upstream of PR Highway 100, and channel improvements for Río Hondo and the Caño Majagual system designed to contain the 100-year storm event.

2.4.2. San Germán Area

(1) **Plan 1.** This plan consists of concrete rectangular channel and levees designed to contain the 100-year storm event.

(2) **Plan 2.** This plan consists of gabion-lined channel improvements and levees to provide protection against the 100-year flood.

(3) **Plan 3.** The plan consists of a levee system along both banks of the river designed to provide 25-year flood protection.

(4) **Plan 4.** The plan consists of channel improvements and replacement of bridge at PR Highway 119 to provide protection against the 10-year flood. This plan does not include levee construction.

2.4.3. **Final Alternatives.** The plans maximizing the net NED benefits are Plan 2 (100-year flood protection) for the Mayagüez-Hormigueros area and Plan 4 (10-year channel improvements and bridge replacement) for the San Germán area. These two plans will be compared against the No Action Alternative and the two originally proposed alternatives Plan 1 (Mayagüez) and Plan 3 (San Germán).

2.4.4. **No Action Alternative.** No flood control measures would be implemented.

2.4.5. **Alternative Plan 1. Mayagüez.** A floodwall would begin at PR Highway 102 just south of the San José development. After extending for 900 meters along the southern and eastern border of the development, a levee will follow and would turn and continue southeast, just south of the developed area along PR Highway 2, for about 3.1 kilometers to its intersection with the west bank of Río Hondo. The main levee would resume on the east bank of Río Hondo and would continue eastward about 1,500 meters to an urban development which was built on a previously existing knoll above the 100-year flood event elevation just west of PR Highway 100. A short section of levee would then be required to connect the east side of the development with the PR Highway 100 bridge approach. Construction of the main levee would then be continued on the east side of the PR Highway 100 bridge approach and would extend along the south edge of PR Highway 309 for about 900 meters to the west bank of an unnamed tributary. The levee would resume on the east side of the tributary and would continue another 900 meters to tie into high ground just north of PR Highway 2. At the two points where the levee is interrupted by tributary inflow, tie-back levees would be required. On the smaller nameless tributary, the levees would extend along both banks from the main levee northward about 900 meters to high ground just south of PR Highway 114. The Guanajibo Homes development would be protected by a ring levee about 1.1 kilometers long with a uniform crest elevation of 4.3 meters (NGVD). This corresponds to an average levee height above existing ground of about 3.5 meters. Levee side slopes would be grass-lined for the entire length. The P.R. Highway 102 bridge over Río Guanajibo would be replaced as part of this plan. In addition to the tie-back levees proposed along Río Hondo, channel improvements would be required on this tributary from its intersection with the main levee northward to PR Highway 2. At the levee, the improved channel would be trapezoidal with a 30-meter bottom width and 1V on 4H grass-lined side slopes. Channel improvement would be continued upstream for 600 meters where a transition from trapezoidal to vertical-walled channel would begin. This 100-meter transition would result in a vertical-walled, gabion-lined channel with a 30-meter bottom width. The vertical-walled channel would continue about 600 meters further upstream ending just south of PR Highway 2. Proposed improvements would also require construction of a new bridge over Río Hondo at PR Highway 114. The material for the construction of the levee would be obtained from a 900 meter by 300

meter borrow area located in the floodplain. Mitigation for the loss of 24.5 acres (9.9 hectares) of mangroves around San José and Guanajibo Homes Subdivision would include the acquisition of 24.5 acres of bottom land, the removal of topsoil down to surrounding elevations of adjacent mangrove wetlands and the natural succession of mangroves into the newly created area. Once the construction is complete, the excess material removed from the mitigation area and the topsoil excavated from the borrow area will be placed in the 66.7 acre (27.0 hectare) borrow area and landscaped to provide emergent wetland and open-water habitat to mitigate for the 4.5 hectare loss of cattail wetlands.

2.4.6. Alternative Plan 3. San Germán. The levee on the north bank would originate about 550 meters downstream from PR Highway 360 bridge, running parallel to that highway. The levee would continue on the north side of the channel, from the upstream side of the PR Highway 360 bridge approach, eastward about 200 meters where it would tie into existing high ground. Following this point, the levee would extend for 460 meters to PR Highway 119. The levee on the north bank would finish about 450 meters upstream from PR Highway 119 bridge. The levee on the north bank would have a total length of about 1.7 kilometers. The levee on the south bank would consist of three segments of levee similar to the levee on the north bank with a total length of about 1.5 kilometers. Gabion mattress protection would be required on the channel side along most of the levee length on both banks of the river. The bridge at PR Highway 119 would be replaced. The bridge at PR Highway 360 would require channel clean out and gabion mattress erosion protection along the upstream pier extensions. Interior drainage would be accomplished through the placement of flap-gated culverts at five locations.

2.4.7. Alternative Plan 2. Mayagüez. San José development would be protected by both a floodwall and tieback levee similar to Plan 1. However, after the floodwall that surrounds the development an earth levee would continue from station 9+00 in a southeasterly direction parallel to Quebrada Sabalos for about 670 meters, and tie into existing high ground at station 15+70. Crest elevation of this floodwall and levee structure is about 5.6 meters (NGVD). The levee would start on the east bank of Río Hondo and continue southeastward to PR Highway 100 and towards PR Highway 2 similar to plan 1. Río Hondo tieback levees and channel improvements are also similar to plan 1. The Guanajibo Homes development would be protected by a ring levee with a uniform crest elevation of 5.6 meters (NGVD). The PR Highway 102 bridge over Río Guanajibo would not be replaced as part of this plan. The material for the construction of the levee would be obtained from a 900 meter by 300 meter borrow area located in the floodplain. Mitigation for the loss of 27.6 acres of mangroves around San José and Guanajibo Homes Subdivision would include the acquisition of 27.6 acres of bottom land, the removal of topsoil down to surrounding elevations of adjacent mangrove wetlands and the planting of mangroves seeds into the newly created area. Once the construction is complete, the excess material removed from the mitigation area and the topsoil excavated from the borrow area will be placed in the 66.7 acre (27.0 hectare) borrow area and landscaped to provide emergent wetland and open-water habitat.

2.4.8. Alternative Plan 4. San Germán. Channel improvements would begin about 50 meters downstream of PR Highway 360 bridge to end about 700 meters upstream PR Highway 119 bridge. The channel would be trapezoidal with a 65 meter bottom width and gabion-lined side slopes. Scour protection would be provided on the channel bottom in the vicinity of PR Highways 119 and 360 bridges. Scour protection would also be provided at the upstream entrance to the channel. The excavated material would be hauled to an upland area and placed until it could be used as construction material.

2.5. PREFERRED ALTERNATIVE. The preferred alternatives are Plan 2 and Plan 4.

2.6. ALTERNATIVE COMPARISON.

Figure 2.1, Alternative Comparison

RESOURCES	NO ACTION ALTERNATIVE		ALTERNATIVE PLANS 1 AND 3		ALTERNATIVE PLANS 2 AND 4	
	Mayaguez	SAN Germán	Mayaguez	SAN Germán	Mayaguez	SAN Germán
PRIME FARMLAND	NO LOSS	NO LOSS	55.7 HECTARES (137.7 ACRES) LOST	NO LOSS	39.6 HECTARES (97.9 ACRES) LOST	NO LOSS
WATER QUALITY	NO IMPACT	NO IMPACT	HIGH SHORT-TERM TURBIDITY LEVELS FROM CHANNEL WORK AT RÍO HONDO AND CAÑO MAJAGUAL	NO IMPACTS	HIGH SHORT-TERM TURBIDITY LEVELS FROM CHANNEL WORK AT CAÑO MAJAGUAL	HIGH SHORT-TERM TURBIDITY LEVELS FROM CHANNEL WORK AT RÍO GUANAJIBO
HAZARDOUS TOXIC AND RADIOLOGICAL WASTE	NO IMPACTS	NO IMPACTS	NO IMPACTS	CLOSURE OF PETROLEUM TANKS	NO IMPACTS	NO IMPACTS
FLOOD DAMAGE	FLOOD DAMAGE TO 2321 DWELLINGS	FLOOD DAMAGE TO 578 DWELLINGS	MAJOR REDUCTION IN FLOOD DAMAGE. PROVIDE PROTECTION TO	MINOR LEVEL OF FLOOD DAMAGE REDUCTION (25-YEAR)	MAJOR REDUCTION	MINOR LEVEL OF FLOOD DAMAGE PROTECTION (10-YEAR)
NOISE	NO IMPACT	NO IMPACT	MAJOR SHORT-TERM IMPACT	MEDIUM SHORT-TERM IMPACT	MAJOR SHORT-TERM IMPACT	MEDIUM SHORT-TERM IMPACT
MANGROVES	NO LOSS	NO LOSS	MINOR LOSS OF 9.9 HECTARES (24.5 ACRES), MITIGATED WITH CREATION OF 9.9 HECTARES OF MANGROVES	NO LOSS	MINOR LOSS OF 11.2 HECTARES (27.6 ACRES), MITIGATED WITH CREATION OF 11.2 HECTARES OF MANGROVES	NO LOSS

RESOURCES	NO ACTION ALTERNATIVE		ALTERNATIVE PLANS 1 AND 3		ALTERNATIVE PLANS 2 AND 4	
	Mayaguez	SAN Geron	Mayaguez	SAN Geron	Mayaguez	SAN Geron
EMERGENT WETLANDS	NO LOSS	NO LOSS	MINOR LOSS OF 4.5 HECTARES (11.1 ACRES) OF CATTAIL WETLANDS ADJACENT TO Calle MAJAGUAL AND MERLE MARSH. IMPACTS OFFSET BY WETLAND CREATION IN BORROW PIT	NO LOSS	NO IMPACT	NO LOSS
ENDANGERED SPECIES	NO IMPACTS	NO IMPACTS	NO IMPACTS	NO IMPACTS	NO IMPACTS	NO IMPACTS
PTEROCARPUS SPECIES	NO IMPACTS	NO IMPACTS	LONG-TERM MEDIUM LOSS OF 0.8 HECTARES (1.3 ACRES) OF PTEROCARPUS SP.	NO IMPACTS	NO IMPACTS	NO IMPACTS
CULTURAL RESOURCES	NO IMPACTS	NO IMPACTS	NO IMPACTS	NO IMPACTS	NO IMPACTS	NO IMPACTS
AESTHETICS	NO IMPACTS	NO IMPACTS	MAJOR SHORT-TERM IMPACT FROM CONSTRUCTION ACTIVITIES. LONG-TERM MODERATE IMPACT FROM DIKE STRUCTURE	MAJOR SHORT-TERM IMPACT FROM CONSTRUCTION ACTIVITIES. LONG-TERM MODERATE IMPACT FROM DIKE STRUCTURE	MAJOR SHORT-TERM IMPACT FROM CONSTRUCTION ACTIVITIES. LONG-TERM MODERATE IMPACT FROM DIKE STRUCTURE	MAJOR SHORT-TERM IMPACT FROM CONSTRUCTION ACTIVITIES
RECREATION	NO IMPACTS	NO IMPACTS	LOSS OF RECREATIONAL FACILITIES ADJACENT TO GUANAJIRO HOMES SUBDIVISION	LOSS OF RECREATIONAL FACILITIES DUE TO DIKE CONSTRUCTION	LOSS OF RECREATIONAL FACILITIES ADJACENT TO GUANAJIRO HOMES SUBDIVISION	NO IMPACTS

Figure 2.1 (Continued)

RESOURCES	NO ACTION/ALTERNATIVE		ALTERNATIVE PLANS 1 AND 3		ALTERNATIVE PLANS 2 AND 4	
	Mayaguez	SAN German	Mayaguez	SAN German	Mayaguez	SAN German
ECONOMICS	ESTIMATED FLOOD DAMAGE - \$5,738,000 AVG PER YR.	ESTIMATED FLOOD DAMAGE - \$1,318,000 AVG PER YR.	SHORT-TERM DISRUPTION TO TRAFFIC FROM BRIDGE REPLACEMENT. MODERATE SHORT-TERM ECONOMIC STIMULUS TO LOCAL ECONOMY	MODERATE SHORT-TERM ECONOMIC STIMULUS TO LOCAL ECONOMY	SHORT-TERM DISRUPTION TO TRAFFIC FROM BRIDGE REPLACEMENT. MODERATE SHORT-TERM ECONOMIC STIMULUS TO LOCAL ECONOMY	SHORT-TERM DISRUPTION TO TRAFFIC FROM BRIDGE REPLACEMENT. MODERATE SHORT-TERM ECONOMIC STIMULUS TO LOCAL ECONOMY

3.0. AFFECTED ENVIRONMENT.

3.1. INTRODUCTION. The environmental issues that are relevant to the decision to be made are the following:

- a. Impacts on prime farmland
- b. Impacts to water quality
- c. Hazardous, toxic and radiological waste
- d. Flood damage
- e. Noise impacts
- f. Impacts on mangroves
- g. Impacts on emergent wetlands
- h. Endangered species
- i. Impacts on *Pterocarpus species*
- j. Impacts to cultural resources
- k. Impacts on aesthetics
- l. Impacts on recreation
- m. Impacts on economics

3.2. GENERAL DESCRIPTION.

3.2.1. Location. The mouth of Río Guanajibo lies about 3 miles south of the city of Mayagüez on the west central coast of Puerto Rico. The city of San Germán lies on the south bank of the river 18 km upstream from the ocean.

3.2.2. Climate. The climate is warm and humid, with an average temperature of 74° F. and only a small annual variation from the average temperature. Annual rainfall ranges from over 100 inches in the mountains to about 55 inches along the coast. Rainfall is generally heaviest during May and between August and October, and lightest in the period January through March. About once in 25 years as much as 9 inches of rain in 24 hours can be expected on the coastal plain, and more than 12 inches in the mountains.

Once in 100 years, a total of 10 to 16 inches can be expected in 24 hours. Along the immediate coast, the annual evaporation exceeds the average rainfall as a result of warm temperatures and rather constant wind. Hurricanes and tropical storms are important factors in the climate of the area, but the frequency of hurricanes is small. The hurricane season in Puerto Rico is primarily from August through early October.

3.2.3. The Río Guanajibo Basin. The Río Guanajibo originates approximately 10 kilometers northeast of Sabana Grande in the western part of the Cordillera Central mountain range at an elevation of about 800 meters MSL. The drainage basin encompasses an area of about 329 sq. km. The river flows in a generally west-northwesterly direction and empties into the ocean at Mayagüez Bay in the Mona Passage. It flows through portions of the Municipios of Sabana Grande, Maricao, San Germán, Hormigueros, Cabo Rojo, and Mayagüez with a medium gradient as it passes through San Germán and a low gradient where it reaches the Mayagüez coastal plain. The structural portions of the project would be contained within the San Germán and Mayagüez Municipios.

3.2.4. Land Use. Very little of the native vegetation remains in the Mayagüez floodplain; the area has been intensively cultivated and is presently used for cattle grazing or sugarcane production. Sugarcane is grown extensively on bottom lands and other subsistence crops are grown on steep hills in scattered fields. There is a great demand for flat terrain for residential and industrial developments, and some of the better farmland is now being converted for these purposes. As the population grows and the demand for housing increases, there would be encroachment on the floodplain.

3.2.5. Soils. The Coloso-Toa soil association occurs in the flood plain of the study area (USDA, 1975). It is characterized by nearly level relief and scattered ponded areas. Most areas are flooded frequently and are subject to deposition of sediments. The Coloso soils are characterized as somewhat poorly drained and somewhat easily worked. The Toa soils are moderately drained and also easily worked. The minor soils are of the Bajura, Corcega, Dique, Santoni, and Talante series. This association, composed of the two major soils and the minor soil series, has been used for sugarcane for many years, and is well suited for this use after drainage systems have been put in place. Some undrained areas are used for grazing during periods of the year when the water table is not at the surface and there is no hazard of flooding. Soils in the study area that are on the hydric soils list are the Bajura clay (Ba) series. Other land types exhibiting anaerobic characteristics would include Tidal swamps (Td) and Alluvial lands (An). These areas are also considered hydric (Figure 4-1).

3.2.6. Fish and Wildlife Resources. About 75% of the Guanajibo watershed (including all of its floodplain) lies within the subtropical, moist forest ecological life zone. Pastureland and sugarcane occupy a large portion of the study area.

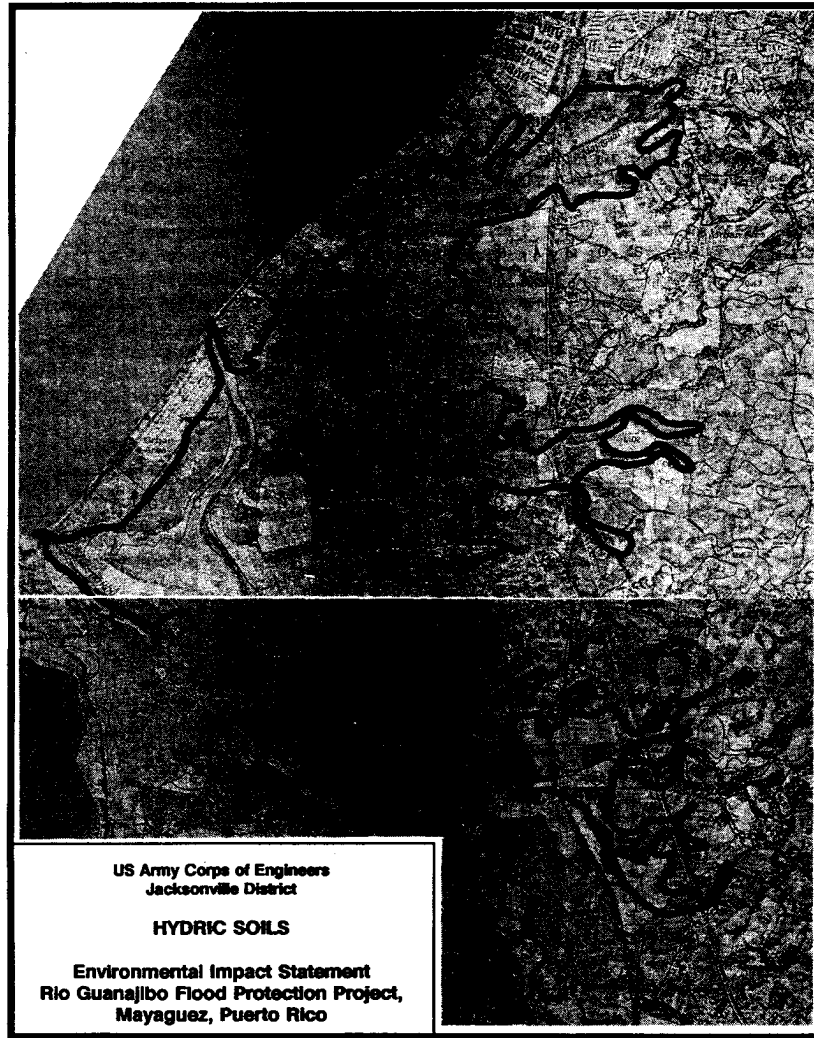
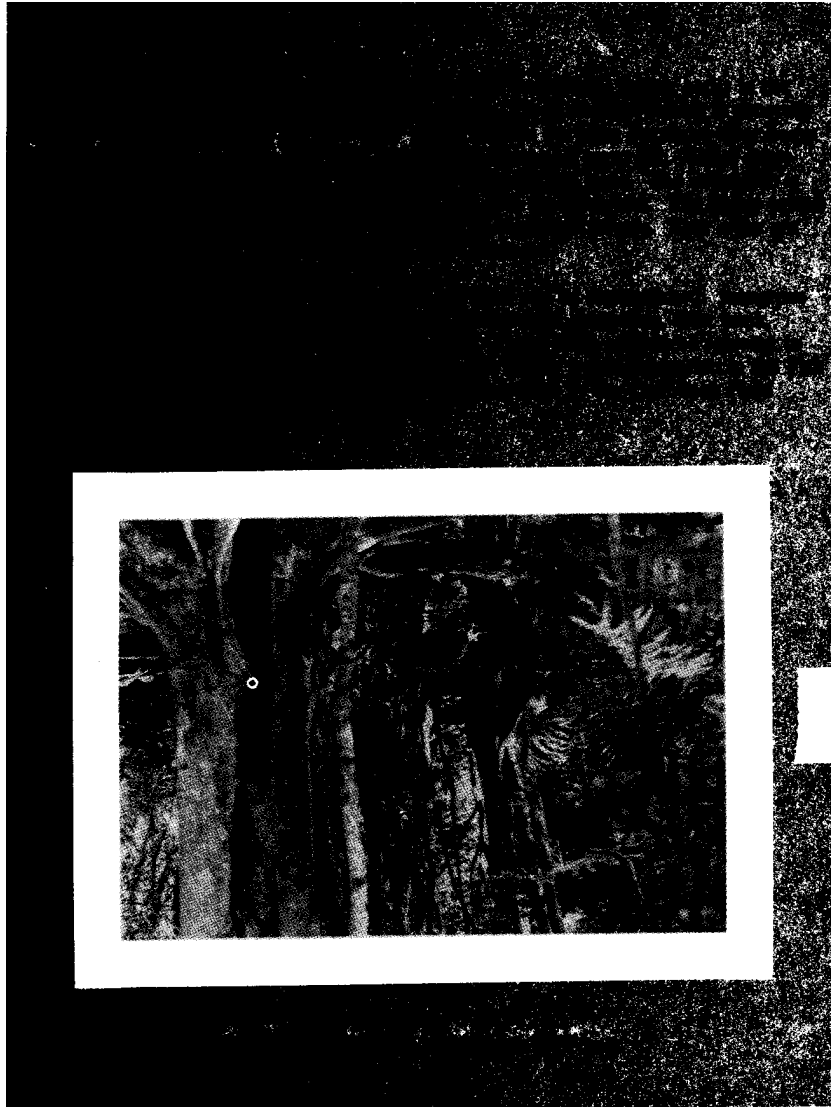


FIGURE 4-1





- a. *Pterocarpus officinalis* (swamp bloodwood) generally occurs in pure stands and in mixed stands with red and white mangroves and a few royal palms (USDA, 1964). The *Pterocarpus* occurs in freshwater-saturated soil at a slightly higher elevation than red mangroves. The mangroves approach their maximum size in this area, with red and black mangroves reaching 17 meters in height. These are among the most robust wetland forests in Puerto Rico, but any appreciable change in flow patterns or reduction in freshwater flooding could eventually eliminate the *Pterocarpus* sp. through competition by red and white mangroves, which can tolerate higher soil salinities. In terms of relative scarcity of the resource and the ecological diversity of the forest, this habitat is considered to be the most ecologically important portion of the study area.
- b. Pastureland. The pastureland habitat is largely devoid of woody vegetation and dominated by panic grasses, patches of facultative wetland herbaceous vegetation, and sometimes containing obligate wetland species such as spike-rush (*Echinocharis* sp.), paspalum (*Echinocloa crusgalli*), and Malanga (*Colocasia esculenta*). When the surrounding ditches become ineffective, the former wet hydrology is restored and the area reverts to a wetland. The pastureland has very little value for wildlife; the vegetative community has been adversely affected by the selective browsing of grazing cattle. However, the emergents provide a food source for birds, especially waterfowl. The open water areas created by the oxbow ponds and the borrow pits in the pastureland provide fish pond habitat. When flood waters inundate these ponds, fish populations are interchanged with those of the Caño Corazones and Río Guanajibo. The borrow pits are surrounded by mangrove trees which provide protection for waterfowl as well as cover and shade for fish. The oxbows are generally without riparian trees because of their location within agricultural areas.
- c. Sugarcane. This area of the floodplain has been drained and converted to the growth of sugarcane. Sugarcane is a monotypic habitat which is planted, burned, and harvested. Herbicides and pesticides are administered to control weeds and pest insects. This habitat only provides cover to small mammals and songbirds and has very low wildlife value.
- d. River Bank. The river bank habitat is a narrow vegetated fringe on each side of the river. It consists of nearly pure stands of bamboo, occasionally interspersed with cana brava (*Gynerium sagittatum*) and mango, almond, coconut palm, or royal palm trees. Within the lower basin floodplain, sugarcane fields have been planted to the edge of the river bank creating a monotypic ground cover with little wildlife value.
- e. Estuarine and Floodplain Areas. Other smaller, important areas include oxbow meanders within the floodplain and old borrow pits adjacent to PR Highway 102 between Guanajibo Homes and the Guanajibo Bridge. Crustaceans

and mollusks are abundant and a high diversity of other invertebrates are found in the soft bottom sediments of the waterways. The adjacent estuarine food web is supported by the export of organic material from these wetlands when they are flushed by pulses of river flow (USFWS, 1991). The tall, dense mangrove stands and adjacent watercourses provide important nesting, roosting, and feeding sites for wading birds, kingfishers, gallinules and coots, warblers, and other birds. The freshwater marshes are not considered particularly important wildlife habitat, but more important for nutrient removal and release of detrital matter into the ecosystem. Wildlife habitat value is moderate to low along the river where it passes through sugarcane fields. A few wading birds forage along the banks, and common songbirds perch in the bamboo or frequent the grassy edges. Such habitat is relatively common in Puerto Rico (Cerames-Vivas, 1973).

3.2.7. Recreational Resources. Demand for recreation opportunities in the Mayagüez and San Germán areas is high. Many people living in the area are willing to invest much of their time and money on their preferred recreational diversion. The available facilities are used at capacity plus and any additional amenities would not go unused for any length of time. The Puerto Rico State Comprehensive Outdoor Recreation Plan shows the preferred activities in the municipio are swimming, walking, basketball, baseball and volleyball. A variety of recreation opportunities currently exist in the proposed project area. Several beach areas for swimming in the Mayagüez area attract the general public: there are athletic fields within easy travel distance; there is fishing in the streams near their confluence with the ocean; and, private recreational facilities are available. The facilities and numbers of each are given in Table 4-1.

TABLE 4-1
RECREATIONAL FACILITIES AVAILABLE IN
Mayagüez AND SAN Germán MUNICIPIOS

FACILITY	NUMBER	FACILITY	NUMBER
Marinas	2	Hunting	2
Polygon	16	Cycling	-
Bioluminescent Bay	-	ORV Riding	-
Caves	9	Swimming, Beach	1
Water Sports	1	Swimming, Pool	8
Roller Skating	-	Private Recreational Facilities	12
Shuffleboard	-	Football	1

FACILITY	NUMBER	FACILITY	NUMBER
Handball Courts	4	Gymnasium	9
Tennis Courts	20	Golf	1
Baseball and Softball	40	Camping	1
Basketball	120	Recreation Center	23
Volleyball	12	Vacation Centers	1
Passive Parks	51	Picnic areas	-
Coat-fighting Rings	4	Athletic Fields	3
Velodromes	1	Soccer	2
Zoo	1		

3.2.8. Socioeconomic Resources. The areas of San Germán and Mayagüez have an estimated population of 154,087 based on extrapolation of the 1980 census. Approximately one-half of the population comprises the labor work force in this area. Development within the municipios of Mayagüez and San Germán over the years has encroached upon the floodplain. The major industry in San Germán in the floodplain area is Johnson & Johnson Laboratory (pharmaceuticals). The major industries in Mayagüez are the commercial fishing cannery, sugarcane and cattle raising.

3.2.9. Cultural Resources. The island of Puerto Rico is rich in cultural and historic resources. The Villa de San Germán, located in San Germán, is one of the oldest permanently occupied settlements in Puerto Rico, and was founded in the 1570's. Two historic properties near the project area in San Germán are listed on the National Register. These two properties, the Convento de Porta Coeli and the Casa de los Ponce de Leon, are located in the city of San Germán. A third structure in San Germán, Casa Juan Ortiz Perchi, has been determined eligible for the National Register, but has not been listed. Near Mayagüez, a number of significant archeological and historic sites are recorded near Mayagüez, including the Estebania Sugar Mill and other nineteenth-century sites within the flood plain which could be associated with the mill, surface scatters of prehistoric and historic period artifacts on low ridges in the Río Guanajibo flood plain, and prehistoric and historic period residential and special use sites on terraces overlooking the flood plain.

3.3. RELEVANT ISSUES.

3.3.1. Physical.

a. **Prime Farmland.** The Coloso and Toa silty clay loam soils are considered Prime Farmland by the Soil Conservation Service (SCS) (USDA, 1989). There are 7,926 acres of Toa silty clay loam (ToA) and 10,599 acres of Coloso silty clay loam (Cn) in

this SCS mapping unit (USDA, 1982).

b. **Water quality.** The Río Guanajibo flows through mostly agricultural areas of the floodplain. Several smaller tributaries carry surface water runoff from municipal and agricultural areas. The municipal runoff contains petroleum products such as oil, gasoline, and antifreeze coolant. Agricultural runoff contains, fertilizers, pesticides and herbicides. The small municipios discharge treated wastewater into the river. The general health of the river is not good.

c. **Hazardous Toxic and Radiological Waste.** A level-1 survey was conducted of the project corridor for potential hazardous, toxic and radiological wastes for such sites as landfills, dumps, and disposal areas, burn areas, underground basins, pits, quarries, wells; indicators such as containers, odors, stressed or dead vegetation; and water treatment plants, storage buildings, and transport facilities where chemicals could be housed such as boat yards, harbors, airports and truck terminals. In the Mayagüez area adjacent to Guanajibo Homes Subdivision and Caño Corazones, an abandoned waste water treatment facility was identified in the project area. In San Germán, two active gasoline stations with underground storage tanks were identified in the project area.

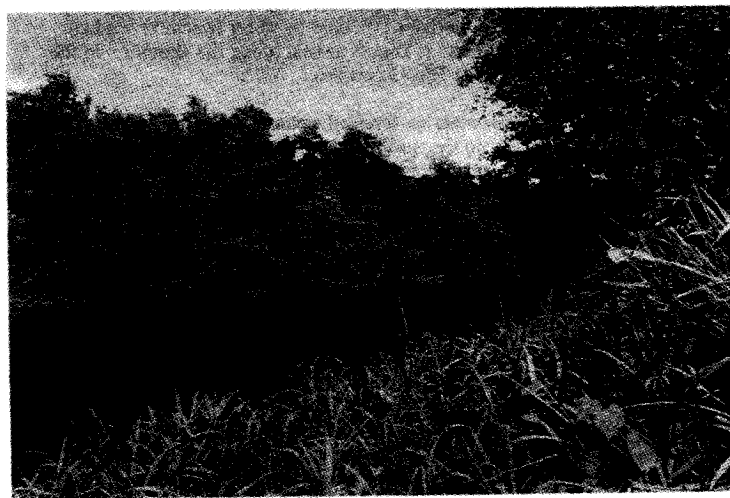
d. **Flooding.** Currently the river floods during a 100-year event elevation in Mayagüez and in San Germán damaging homes and businesses that have encroached upon the flood plain. Flooding routinely damages crops grown on the floodplain. This situation is typical because most of the available productive farmland is located in the floodplain. Safeguarding the lives of some 9,286 inhabitants living along the Río Guanajibo flood plain in the areas of Mayagüez, Hormigueros, and San Germán is considered the ultimate objective of the proposed flood control project. A significant amount of this population belongs to low and low-middle income families striving toward improving their living conditions. All plans would contribute substantially to reduce the threat to life and property damage as a result of major floods in the study area.

e. **Noise.** The existing floodplain is surrounded by mostly residential housing. The floodplain itself is agricultural pasture and sugar cane. The only noise sources are from the occasional harvesting and planting of sugar cane and the constant vehicular road traffic along the coastal highway and the occasional traffic along lateral arterials. In general, the residential housing setting is relatively quiet.

3.3.2. Biological.

a. **Mangroves.** Within the study area, mangroves cover about 282 acres and are confined to the lowest reaches of the Guanajibo basin. Extensive mangrove forests surround Caño Corazones, just north of the mouth of the river. Well developed red mangroves surround the water courses, extending out to a basin forest of white and

which encompasses urban and suburban areas. These changes are driven by land-use trends from suburban sprawl, particularly along the New York City to New Jersey and from Long Beach to the Channel. A major concern has been the impact of the border and adjacent to the highway I-95 between the New Jersey bridge and Connecticut River and water.



PHOTOGRAPH 13. Eugene Wacker.

4. **Subsequent activities.** A large number of individuals have been active in the planning and carrying out of the activities of the Committee. The following persons have been active in the planning and carrying out of the activities of the Committee:

of the mangrove forest. These marshes, which are vegetated primarily with cattail and giant sedge, are important in terms of their role in the hydrology that sustains the mangroves that lie down-gradient. During storms, the marshes store and slowly release flood flows from the adjacent uplands, thereby, extending the vitalizing freshwater input to the mangroves, attenuating the peak flood stages. This regulation of water flow is important for reduction of salinity and maintenance of water quality in the mangrove forests. In addition, these marshes also provide a physical and biological filtering capacity that is thought to serve an important role in maintaining water quality through nutrient uptake and control of sedimentation.

c. **Endangered species.** The endangered West Indian manatee is frequently observed in the mixing zone at the mouth of the river, and after heavy rains, they ascend the river for short distances, perhaps attracted by water hyacinths washed down in the floods. The brown pelican is known to nest along the shoreline in the Industrial Park near the mouth of the Río Guanajibo.

d. ***Pterocarpus* species.** A *Pterocarpus* *sp.* forested wetland, covering approximately 7 acres, lies immediately adjacent to the north bank of the Guanajibo River near its mouth. Another small forested wetland containing *Pterocarpus* *sp.* and mangroves lies adjacent to the mouth of the Caño Majagual.

3.3.3. Social.

a. **Cultural resources.** A cultural resources reconnaissance survey was conducted along portions of the study area in 1986-87. Archival and background data were collected during the survey, utilizing information from the Puerto Rico State Historic Preservation Officer (SHPO) and the National Register of Historic Places. Field investigations included pedestrian reconnaissance, shovel testing, and deep auger testing. The subsurface tests were judgementally placed to examine areas of high archeological site potential. During the reconnaissance survey, 10 potentially significant archeological sites were recorded or revisited in the Mayagüez tract. Three previously unrecorded archeological sites were located in the San Germán tract. No surveys have been conducted within the tract of land that would be used for the storage of excavated material obtained from channel work in San Germán. Surveys would be conducted during the Detailed Engineering Phase. Neither of the two alternative plans would affect historic properties listed on or eligible for listing on the National Register of Historic Places.

b. **Aesthetic resources.** The beaches and palm trees along the Highway 102 near Mayagüez provide a serene setting for picnics, fishing, and swimming. The residential and farming areas along the Río Guanajibo overlook the scenic floodplain area with mountainous areas for a backdrop. Oxbow ponds provide a gathering place for waterfowl. Birdwatchers can spot a variety of avian species in this area. San Germán is a small historic city that lies in a valley surrounded by

large hills. The Río Guanajibo flows through this small historic municipio on its way to the ocean. The presence of this normally gently moving water provides a tranquil setting for the inhabitants of San Germán.

c. **Recreation.** A community recreation area is located adjacent to the south bank of the Río Guanajibo in San Germán at the PR Highway 360 Bridge. Facilities include a baseball field, basketball court, band shell and community recreation building. A basketball court and bleachers is located adjacent to the Guanajibo Homes Subdivision and Caño Corazones in Mayagüez.

3.3.4. **Economic impacts.** The flood damages are estimated to be \$60,715,000 for the 100 year flood occurrence. Mayagüez also has a commercial area adjacent to the Río Hondo which has numerous businesses and industries. The floodplain provides areas for growing crops of sugarcane and areas for grazing cattle for beef or milk production. In doing so, flood damages and threats to human life have been substantial and continue to increase during flood events. Guanajibo and San José Homes subdivisions are built along the coast in the middle of the floodplain. During intensive floods, not only are these homes flooded but all road access is cut off for emergency care and evacuation along Highway 102. The threat of floods, damages to property and loss of lives weighs heavily on the inhabitants of these areas.

4.0. ENVIRONMENTAL CONSEQUENCES.

4.1. **INTRODUCTION.** This section describes the probable consequences of implementing each alternative on selected environmental resources. These resources are directly linked to the relevant issues listed in Section 1.4 that have driven and focus the environmental analysis.

4.2. NO ACTION ALTERNATIVE.

4.2.1. Physical

- a. Prime farmland. There would be no adverse impacts on Prime Farmland.
- b. Water quality. There would be no adverse impacts on water quality.
- c. Hazardous Toxic and Radiological Waste. There would be no impacts associated with hazardous or toxic waste from the selection of this alternative.
- d. Flood damage. There would be continued flood damage to residential and commercial properties in Mayagüez, Hormigueros and San Germán. The flood potential would continue to cause physiological distress to the 9,286 residents along the Río Guanajibo floodplain.

- e. Noise. There would be no change in noise levels.

4.2.2. Biological

- a. Mangrove wetlands. There would be no adverse impacts on mangrove wetlands.
- b. Emergent wetlands. There would be a some loss of emergent wetlands from the encroachment of residential and commercial development on the floodplain. Section 404 of the Clean Water Act would regulate this development.
- c. Endangered species. There would be no adverse impacts on endangered species.
- d. Pterocarpus species. There would be no impacts on these forested wetlands.

4.2.3. Social

- a. Cultural Resources. No historic properties listed on or eligible for listing on the National Register of Historic Places would be impacted by the existing conditions.
- b. Aesthetics. Without the project the heavy vegetation in the lower basin would remain unchanged. Mangroves, stands of *Pterocarpus* sp. and other riverine vegetation would continue to alternate between flooded and dry conditions. The natural beauty of this area with its views to the distant mountains would remain in a largely unspoiled state.
- c. Recreation. The recreational facilities in San Germán and at the Guanajibo Homes Subdivision in Mayagüez would continue to be flooded periodically.

4.2.4. **Economic impacts.** The flood damages for a 100-year event are estimated at \$60,715,000.

4.2.5. **Cumulative effects.** There would be no cumulative effects from the selection of this alternative.

4.2.6. **Unavoidable effects.** There would be no unavoidable effects from the selection of this alternative.

4.2.7. **Irreversible and Irretrievable Resource Commitments.** There would be no irreversible or irretrievable commitment of resources from the selection of this alternative.

4.3. ALTERNATIVE Plan 1 and Plan 3

4.3.1. Physical

a. Prime farmland. There would be a loss of approximately 137.7 acres (55.7 hectares) of agricultural lands considered to be Prime farmland by the Soil Conservation Service. This loss would result from the construction of the levee and adjacent drainage canals and from the excavation of construction material within the borrow area and from the creation of a 24.5-acre mitigation area (Farmland Conversion Impact Rating - 124.5), Exhibit VII). In the San Germán borrow area, the soils were mapped as Toa and Reilly soil types. Even though these soil types are considered Prime Farmland, they have been previously excavated and have lost their characteristics that would make them prime. This loss represents a reduction of 0.15% of Coloso soils and 1.5% of the Toa soils in this mapping unit.

b. Water quality. Water quality would not be adversely impacted by the placement of fill in the mangrove and emergent wetlands within Merle Marsh and would therefore, meet Commonwealth water quality standards. The channelization of Río Hondo and Caño Majagual would cause some short-term increases in turbidity within the stream. Over the long-term, as the streams stabilize turbidity levels would decline to background levels. No long-term adverse impacts would occur.

c. Hazardous Toxic and Radiological Waste. In Mayagüez, the residual wastes from abandoned sewage treatment plant would have to be disposed of properly. In San Germán, two gasoline stations adjacent to the PR Highway Bridge 119 would have to be closed. This includes removal of the underground fuel storage tanks.

d. Flood damage. Flood waters equal to the 100-year event would be contained within the levees and floodwalls in Mayagüez. In San Germán, flood waters equal to the 25-year event would be contained within the levee system. Greater flood events would cause catastrophic failure of the levee, significant property loss and potentially human life. Plan 1 in the Mayagüez-Hormigueros area would provide direct protection to 7,700 persons in the lower valley. In the San Germán area Plan 1 would provide limited protection to the local population.

e. Noise. In Mayagüez, there would be a major short-term increase in noise levels from the presence and operation of heavy equipment to excavate and transport materials to the levee construction site, from the placement of material and the construction of the levees. Noise impacts from truck traffic would occur along a corridor from the borrow site to the levee locations and from the mitigation site to the borrow area. In San Germán, there would also be major short-term noise impacts from the excavation of channel materials and the transportation of those materials to a storage area. There would be less contact with residential housing areas and a smaller project than Mayagüez, therefore, there would be less impacts on the human environment. These impacts are considered short-term because they would occur during the construction period.

4.3.2. Biological

a. **Mangrove wetlands.** There would be a loss of approximately 24.5 acres (9.9 hectares) of mature mangroves surrounding Guanajibo Homes and San José Homes Subdivisions. This impact would be offset by the creation of 24.5 acres of mangroves adjacent to the Caño Corazones. This area is located between mangroves growing along the Caño Corazones and mangroves located behind the Guanajibo Homes Subdivision. There would be rapid colonization of this area by mangroves as the seed source is readily available, a tropical climate with long growing season is present, and the substrate would be adjusted to the proper elevations to allow for tidal influence of the area. During the short period of time before full canopy closure, there would be a period of succession from mud flats, to emergent wetland vegetation, to scrub-shrub wetlands and finally to full mangrove forest. These successional stages would provide feeding, loafing, and nesting for various wading and shorebirds along the coast.

b. **Emergent wetlands.** There would be a direct long-term loss of 4.5 hectares (11.1 acres) of cattail wetlands along Caño Majagual from the channelization and from levee construction in the vicinity of Merle Marsh, and a short-term loss of cattails due to a 5 meter width construction area adjacent to the Caño Majagual channel. These losses would be offset by the creation of freshwater wetlands in the borrow area.

c. **Endangered species.** No endangered species would be adversely affected by this alternative.

d. **Pterocarpus species.** Channelization would impact 0.6 hectares (1.5 acres) of mixed *Pterocarpus sp.* forest located at the mouth of Caño Majagual.

4.3.3. Social

a. **Cultural Resources.** No historic properties listed on or eligible for listing on the National Register of Historic Places would be affected by this alternative.

b. **Aesthetics.** Floodwalls and levees would provide a visual barrier towards the horizon to those living closest to them. Views to the distant mountains would be reduced for many residents. Grassing the levees would provide some visual relief for the residents of the area and lessen the "confined" feeling created by these structures. Climbing to the levee crest would provide a platform for viewing birds and other wildlife. This would help to offset any negative visual impacts of the levees. Negative visual impacts of a bare concrete floodwall at San José homes can be offset by following the guidance set forth in Policy Guidance Letter No. 29, dated 15 August 1991 as well as in Engineering Regulations and Engineering Manuals currently in effect. The Guidance Letter stresses the Federal responsibility to

harmoniously blend projects with the surrounding environment while avoiding excessive expenditures. Engineering Regulation 1105-2-100, and Engineering Manuals 1110-2-38, 1110-2-301 and 1110-2-1205 provide guidance for incorporating aesthetic treatments into projects during construction to achieve this blending with the environment. Any aesthetic treatments selected would be closely coordinated with the non-Federal project sponsor, who must share in the additional expense involved. The levee at San Germán would also be blended with the environment using landscaping materials as screening to minimize any negative visual impacts in accordance with these directives.

c. Recreation. The basketball court at the Guanajibo Homes Subdivision would be eliminated. The levees in the lower end of the project area could be designated for use by pedestrian traffic, but would not have a formal trail system added to them. Bollards would be used to prevent motorized vehicle traffic from accessing the levees. No additional recreational facilities would be added at San Germán.

4.3.4. Economic. Residences and commercial buildings within the floodplain would be affected by the project. These impacts would be mitigated by the relocation, in the Mayagüez area, of twenty-three residences, three commercial buildings and several minor structures. In San Germán, three residences, two commercial structures and one governmental structure would be relocated. There would be reduction in flood damages to both communities and a greater peace of mind from the relief from flooding impacts. The recreational facilities created in conjunction of levee construction would promote greater social interaction among local residents. The levee would also create an access to the ocean to residents living in Mayagüez and Hormigueros. Where there are farming operations that would be interrupted by the construction, access would be created so the farming operations could continue. There would be short-term moderate economic stimulus to the local economy from the sale of goods and services and contracting for labor in support of the construction activities.

4.3.5. Cumulative effects. There would be no cumulative effects from the selection of this alternative.

4.3.6. Unavoidable effects. The unavoidable effects include loss of 189.0 acres (76.5 hectares) of Prime Farmland, the loss of 24.5 acres (9.9 hectares) of mangroves, the loss of 0.6 acres (0.25 hectares) of mixed *Pterocarpus* sp. forest, and the loss of 11.1 acres (4.5 hectares) of emergent wetlands. There would be major short-term noise impacts from the presence and operation of heavy equipment from the excavation of materials, the transport of materials and the construction of the levees and mitigation site.

4.3.7. Irreversible and Irretrievable Resource Commitments. There would be the loss of 189.0 acres of agricultural land, 24.5 acres of mangroves, 0.6 acres of mixed *Pterocarpus* sp. forest and 11.1 acres of cattail wetlands. In addition there would be the use of fuel expended for the operation of heavy equipment during construction.

4.4. ALTERNATIVE Plan 2 and Plan 4

4.4.1. Physical

- a. **Prime Farmland.** There would be a loss of approximately 97.9 acres (39.6 hectares) of agricultural lands considered to be Prime farmland by the Soil Conservation Service (Farmland Conversion Impact Rating - 121.3, Exhibit VII). This loss would occur due to the construction of the levee and adjacent drainage canals and from the excavation of construction material within the borrow area.
- b. **Water quality.** There would be no adverse impacts from the placement of fill material into mangrove wetlands from the construction of the levees and floodwalls around Guanajibo Homes and San José Homes Subdivisions. There would be some high turbidity levels during the construction of the channels at Caño Majagual in Mayagüez and in San Germán on the Río Guanajibo.
- c. **Hazardous Toxic and Radiological Waste.** In Mayagüez, the residual wastes from abandoned sewage treatment plant would have to be disposed of properly. In San Germán, two gasoline stations adjacent to the PR Highway Bridge 119 would have to be closed. This includes removal of the underground fuel storage tanks.
- d. **Flood damage.** Flood waters equal to the 10-year event would be contained within the new channel. No catastrophic impacts are anticipated.
- e. **Noise.** There would be a major short-term increase in noise levels from the presence and operation of heavy equipment to excavate and transport materials to the levee construction site, from the placement of material and the construction of the levees. Noise impacts from truck traffic would occur along a corridor from the borrow site to the levee locations and from the mitigation site to the borrow area. In San Germán, there would also be major short-term noise impacts from the excavation of channel materials and the transportation of those materials to a storage area. There would be less contact with residential housing areas than in Mayagüez, and this would be a smaller project. Therefore, there would be less impacts on the human environment. These impacts are considered short-term because they would occur during the construction period.

4.4.2. Biological

- a. **Mangrove wetlands.** There would be a loss of approximately 27.6 acres (11.2 hectares) of mature mangroves surrounding Guanajibo Homes and San José Homes Subdivisions. Approximately 6.0 acres of mangroves would be gradually lost due to the construction of a levee and floodwall around the radio station adjacent to Guanajibo Homes Subdivision. The isolation of this area from tidal estuary would reduce the salinity in this area causing the eventual extirpation of the mangroves and

the conversion to a more freshwater environment such as cattail. This impact would be offset by the creation of 27.6 acres of mangroves adjacent to the Caño Corazones. This area is located between mangroves growing along the Caño Corazones and mangroves located behind the Guanajibo Homes Subdivision. There would be rapid colonization of this area by mangroves as the seed source is readily available, a tropical climate with long growing season is present, and the substrate would be adjusted to the proper elevations to allow for tidal influence of the area. During the short period of time before full canopy closure, there would be a period of succession from mud flats, to emergent wetland vegetation, to scrub-shrub wetlands and finally to full mangrove forest. These successional stages would provide feeding, loafing, and nesting for various wading and shorebirds along the coast.

b. **Emergent Wetlands.** There would be no loss of freshwater wetlands from this construction. There would be a creation of some freshwater wetlands within the borrow area from the excavation of material to construct the levees in the area. The exact amount is not known at this time and is dependent on the quantity of material necessary for construction and the amount of material deposited from the construction of the mitigation area.

c. **Endangered Species.** There would be no adverse impacts on endangered species.

d. **Pterocarpus species.** There would be no impacts on these forested wetlands from this alternative.

4.4.3. Social

a. **Cultural Resources.** No historic properties listed on or eligible for listing on the National Register of Historic Places would be affected by this alternative. Additional surveys would be conducted within the tract of land that would be used for storage of the excavated material. If cultural sites are found they would be avoided or if the SHPO determines, the resources could be recovered.

b. **Aesthetics.** Floodwalls and levees would provide a visual barrier towards the horizon to those living closest to them. Views to the distant mountains would be reduced for many residents. Grassing the levees would provide some visual relief for the residents of the area and lessen the "confined" feeling created by these structures. Climbing to the levee crest would provide a platform for viewing birds and other wildlife. This would help offset any negative visual impacts of the levees. Negative visual impacts of a bare concrete floodwall at San José homes can be offset by following the guidance set forth in Policy Guidance Letter No. 29, dated 15 August 1991 as well as in Engineering Regulations and Engineering Manuals currently in effect. This would reduce any resentment of the wall by residents in the subdivision and minimize any negative visual impacts of aesthetic quality. Any aesthetic treatments selected would be closely coordinated with the non-Federal

project sponsor, who must share in the additional expense involved. The channel work at San Germán would be blended into the environment as much as possible to minimize any negative visual impacts in accordance with these directives. Landscaping materials would be used as screening where possible.

c. **Recreation.** The basketball court at the Guanajibo Homes Subdivision would be eliminated. The levees in the lower end of the project area could be designated for use by pedestrian traffic, but would not have a formal trail system added to them. Bollards would be used to prevent motorized vehicle traffic from accessing the levees. No additional recreation facilities would be added at San Germán.

4.4.4. **Economic.** There would be a short-term disruption to the traffic patterns in San Germán from the replacement of the PR Highway 102 Bridge. There would be a short-term moderate economic stimulus to the local communities from the sale of goods and services and contracting for labor in support of the construction.

4.4.5. **Cumulative effects.** There would be no cumulative effects from this alternative plan.

4.4.6. **Unavoidable effects.** The unavoidable effects include loss of 141.8 acres (57.4 hectares) of Prime Farmland and the loss of 27.6 acres of mangroves. There would be major short-term noise impacts from the presence and operation of heavy equipment from the excavation of materials, the transport of materials and the construction of the levees and mitigation site.

4.4.7. **Irreversible and Irretrievable Resource Commitments.** There would be the loss of 141.8 acres of agricultural land and 27.6 acres of mangroves wetlands. In addition there would be the use of fuel expended for the operation of heavy equipment during construction.

5.0. LIST OF PREPARERS. The following professionals prepared the draft Environmental Impact Statement for the Río GuanaJibo Flood Protection Project.

NAME	DISCIPLINE	EXPERIENCE	ROLE IN PREPARING EIS
William J. Forfierek	Biologist	18 years environmental impacts assessment	EIS Coordinator; Biological Impact Assessment; Endangered Species Coordination
Roberto Cortes	Hydraulic Engineer	12 years planning experience	Project Manager
Arnon I. Bozeman	Outdoor Recreation Planner	15 years experience recreation design, construction and development	Recreation Resources Analysis and Mitigation Development
Scott Burch	Geotechnical Engineer	3 years geotechnical	Geotech studies
David L. McCullough	Archaeologist	14 years cultural resources assessment	Cultural Resources
Ivan Acosta	Environmental Engineer	3 years	HTRW and Water Quality Investigations and Impact Assessment

6.0. CONSULTATION WITH OTHERS - PUBLIC INVOLVEMENT PROCESS.

6.1. SCOPING. During the Reconnaissance Phase of this study, a scoping letter was sent to all interested parties by letter dated December 13, 1988, notifying them of the project plans and asking for information and comments designed to aid in the preparation of this document.

6.2. PUBLIC AND AGENCY MEETINGS

6.2.1. General

a. The Planning Board (PRPB) is the responsible for the programming of funds for most of the public work and land use in Puerto Rico. The Department of Natural and Environmental Resources (DNER), the local sponsor, is responsible for the programming, designing and construction of flood control measures in Puerto Rico. Flood control measures can also be implemented by municipal governments but they will have to be coordinated with the PRPB and DNER. The US Army Corps of Engineers (Corps) maintains a very active communication/coordination process with the PRPB and DNER. The Corps provides comments by request to every significant project (private or public) in floodable areas that has being under consideration by the PRPB and DNER for the last 20 years. The DNER is the sponsor of all the Corps flood control studies and construction projects in Puerto Rico. Although the Río Guanajibo feasibility study is totally funded by the Federal government, the DNER has participated in the process and has being provided with detailed information on progress and requirements since the beginning of the study. The DNER serves as the Corps main contact with the local government and general public in the planning, programming and construction of flood control projects in Puerto Rico.

b. In addition, extensive information and coordination efforts has being provided and implemented with the municipal governments, state and local Civil Defence offices and the general public. On 14 July 94 an executive summary (Spanish version) was disseminated to all residents and commercial activity to be directly impacted/affected by the construction of proposed flood control project.

6.2.2. Public and Agency Meetings

a. **Public Meetings.** To initiate the study process a public meeting was held on 19 August, 1980, 7:30 PM, San Germán. A transcript of the meeting is available at the Antilles Office. A public meeting to present study results and recommendations was held on 23 August 1994 at 2:00 PM in San German and at 7:00 PM in the Mayaguez-Hormigueros area. A summary transcript is contained in the Feasibility Study Appendix D.

b. **"Asociación Pro-Damnificados Huracán Eloísa".** This organization associates

residents (over 200 families) in the San German area affected by floods from Hurricane Eloisa in Sept 1975. Since 1976, on the second or third sunday of the month of February this organization celebrates their annual meeting to receive information and request action/assistance from the local government in solving or reducing problems affecting the Río Guanajibo floodable area. Through the years, the Corps has participated in these meetings and provided this association information and assistance in reference to flood plain management and status reports on the Río Guanajibo feasibility study. The current president of this organization, Mr. Jorge López Zapata has provided active assistance in the dissemination of the information on the study process.

c. DNER (local sponsor). Intensive coordination with this agency occurs through the year. Every year DNER prepares a significant portion of their funding request based on information provided through meetings with the Corps, Planning Section in the Antilles during the month of September. These meetings provides good opportunity to discuss issues associated with the program to include the Río Guanajibo Feasibility study. As part of its flood control and bank stabilization program, the DNER designed and constructed a gabion-lined project along Río Guanajibo at San German. The design and construction process took about 5 years and was completed (about 95%) in late 1993. During this design and construction process a significant amount of coordination meetings took place to integrate DNER and Corps projects. Also, in several occasions DNER requested technical support from the Corps in the development of the project. Within the last two years several coordination meetings and field visits have being held between the DNER and Corps in relation to the Río Guanajibo Feasibility Study. Following is a detailed account of some of the most significant meetings or field trips associated with this study:

1). In 1993. 13 and 21 Jan, 24 and 25 Feb, 31 March, 14 June, 14, 15 and 28 Jul, 20 Oct, and 16 and 17 Dec.

2). In 1994. 9 and 14 Feb, 13 Apr, and 7, 10, and 13 June.

6.3. DEIS COORDINATION. The copy of the Draft EIS was sent to all interested parties by letters dated 6 and 11 July 1994 for a 45-day comment period. A list of addresses is contained in the Coordination Exhibit VII. The comments and responses are also located in Appendix VII.

6.4. Notice of Availability. By letter dated 1 July 1994, 5 copies were submitted to EPA to prepare a Notice of Availability. A notice of Availability of the Draft EIS for comment was published in the Federal Register, Vol. 59, No. 135, dated 15 July 1994.

8.0. REFERENCES

- Adamus, P R., Clairain, E.J., Smith, R.D., and Young, R.E., 1987. "Wetland Evaluation Technique (WET), Volume II: Methodology", Operational Draft Technical Report Y-87-__, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.
- Bacon, Peter R., 1988. "Freshwater Foodchains of Caribbean Island Wetlands", *Acta Cientifica* 2(2-3): 74-93.
- Cerame-Vivas, M.J., 1973. "Mangroves of Puerto Rico".
- Daniel T. Elliott, Garrow and Associates, Inc. 1987. "Archaeological Reconnaissance of Five Tracks in the Río Guanajibo Basin, Puerto Rico" Manuscript on file, U.S. Army Corps of Engineers, Jacksonville District
- Federal Interagency Committee for Wetland Delineation, 1989. "Federal Manual for Identifying and Delineating Jurisdictional Wetlands". US Army Corps of Engineers, US Environmental Protection Agency, US Fish and Wildlife Service, and the USDA Soil Conservation Service, Washington DC, Cooperative Technical Publication.
- Little, E.L. and Frank H. Wadsworth, 1964. "Common Trees of Puerto Rico and the Virgin Islands", Agricultural Handbook No. 249, USDA, Forest Service, Washington, DC.
- López, José M., Allan W. Stoner, Jorge R. García, and Iván García-Muñiz, 1988. "Marine Food Webs Associated with Caribbean Island Mangrove Wetlands", *Acta Cientifica* 2(2-3): 94-123.
- Lugo, Ariel E. and Sandra Brown, 1988. "The Wetlands of Caribbean Islands", *Acta Cientifica* 2(2-3): 48-61.
- Lugo, Ariel E. and Sandra Brown, 1988. "Evaluation of Functional Predictors to Wetlands of Caribbean Islands", *Acta Cientifica* 2(2-3): 125-130.
- US Department of Agriculture, Soil Conservation Service, 1975. "Soil Survey of Mayagüez Area of Western Puerto Rico".
- US Department of Agricultural, Soil Conservation Service, 1985. "Hydric Soils of Puerto Rico". First Edition.
- US Department of The Interior, US Fish and Wildlife Service, 1988. "National List of Plant Species that Occur in Wetlands: Caribbean (Region C)", Biological Report 88(26.12).

SECTION 404(b)(1) EVALUATION FILL MATERIAL

I. Project Description

a. **Location.** The flood protection project is located in the southwestern part of Puerto Rico in the municipios of Mayaguez and San Germán.

b. **General Description.**

(1) The project at Mayaguez involves the placement of fill material into waters of the United States from the construction of a floodwall and levee system around San José Homes and Río Guanajibo Homes Subdivisions.

c. **Authority and Purpose.** Authority and funds for this project are provided by Section 204 of the Flood Control Act of 1970. The purpose of the study is to reduce long-term flood damages along the Río Guanajibo.

d. **General Description of Dredged or Fill Material**

(1) **General Characteristics of Material.** Geotechnical studies of the material in the borrow areas have been conducted (Appendix A). The material to be used for the levees would consist of soils taken from the floodplain borrow area.

(2) **Quantity of Material.** The floodwall base and levee would be constructed with 325,000 cubic yards of material.

(3) **Source of Material.** The fill material would be excavated from a borrow area located in the floodplain (Plates 6A).

e. **Description of the Proposed Discharge Site.**

(1) **Size and Location.** The discharge of fill material will occur in the mangrove swamps adjacent to the San Jose and Guanajibo Homes Subdivisions.

(2) **Type of Site.** The mangrove swamp would be a confined as part of the levee structure.

(3) **Type of Habitat.** The levees around Guanajibo Homes and San Jose Homes are mature mangrove forests.

(4) **Timing and Duration of Discharge.** The time and duration have yet to be determined.

f. **Description of Disposal Method.** The borrow material will be placed using heavy equipment. The side slopes of the levees and base of the floodwalls would be stabilized to prevent erosion.

II. Factual Determinations

a. Physical Substrate Determinations.

(1) **Substrate Elevation and Slope.** The discharge site is relatively flat with a ground elevation ranging between 0.5 and 1.5 MSL.

(2) **Sediment Type.** The soils in the area are silty clays to clayey in nature.

(3) **Dredged/Fill Material Movement.** The fill material will be used for the construction of levees and will not be subject to erosive forces. The fill slopes will be stabilized to prevent erosion.

(4) **Physical Effects on Benthos.** Not applicable.

(5) **Other Effects.** No other physical affects are anticipated.

(6) **Actions Taken to Minimize Impacts.** Alternative levee designs were considered which would avoid impacts to wetlands. A segment of levee around Merle Marsh was eliminated. A floodwall was constructed around San Jose Subdivision to reduce the amount of fill required and amount of mangroves impacted. Side slopes of the levees will be stabilized to prevent erosion.

b. Water Circulation, Fluctuation and Salinity Determinations

(1) Water

(a) **Salinity.** Not applicable.

(b) **Water Chemistry.** Not applicable.

(c) **Clarity.** Not applicable.

(d) **Color.** Not applicable.

- (e) Odor. Not applicable.
- (f) Taste. Not applicable.
- (g) Dissolved Gas Levels. Not applicable.
- (h) Nutrients. Not applicable.
- (i) Eutrophication. Not applicable.

(2) Current Patterns and Circulation. Not applicable.

(3) Normal Water Level Fluctuations. The levees will interrupt flood waters from inundating certain inhabited portions of the floodplain.

(4) Salinity Gradients. Not applicable.

(5) Actions That Will Be Taken to Minimize Impacts. None.

c. Suspended Particulate/Turbidity Determinations

(1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site. Not applicable.

(2) Effects (degree and duration) on Chemical and Physical values

(a) Light penetration. Not applicable.

(b) Dissolved Oxygen. Not applicable.

(c) Toxic Metals and Organics. No toxic or organic pollution sources have been identified in the project area.

(d) Pathogens. Not applicable.

(e) Aesthetics. There would be a substantial short-term impact on the area from the presence and operation of heavy equipment. Over the long-term, the presence of a levee would interrupt the normal scenic landscape. However, as this area gets revegetated and the local citizenry become accustomed to its presence the levee and other structures will become less aesthetically offensive.

(f) Others as Appropriate. Not applicable.

(3) Effects on Biota (consider environmental values in Section 230.21, as appropriate)

- (a) Primary Production, Photosynthesis. Not applicable.**
- (b) Suspension/Filter Feeders. Not applicable.**
- (c) Sight Feeders. Not applicable.**

(4) Actions taken to Minimize Impacts. None.

d. Contaminant Determinations. No sources of pollution have been identified in the project area, therefore, no contaminants are expected to be encountered.

e. Aquatic Ecosystem and Organism Determinations

- (1) Effects on Plankton. Not applicable.**
- (2) Effects on Benthos. Not applicable.**
- (3) Effects on Nekton. Not applicable.**
- (4) Effects on Aquatic Food Web. Not applicable.**
- (5) Effects on Special Aquatic Sites.**
 - (a) Sanctuaries and Refuges. Not Applicable.**
 - (b) Wetlands. There would be a loss of approximately 27.6 acres of mangrove forest.**
 - (c) Mud Flats. Not applicable.**
 - (d) Vegetated Shallows. Not applicable.**
 - (e) Coral Reefs. Not applicable.**
 - (f) Riffle and Pool Complexes. Not applicable.**
- (6) Threatened and Endangered Species. A No Effect determination has been reached and concurred with by the US Fish and Wildlife Service and the National Marine Fisheries Service.**
- (7) Other Wildlife. Not applicable.**

(8) **Actions to Minimize Impacts.** The design has been changed from a levee to a flood wall in the location of San Jose Homes to minimize impacts on mangrove forest wetlands. A 27.6 acre mangrove wetland area will be established to offset the loss of 27.6 acres of mangrove that would unavoidably be lost.

f. **Proposed Disposal Site Determinations**

(1) **Mixing Zone Determination.** Not applicable.

(2) **Determination of Compliance with Applicable Water Quality Standards.** The discharge will comply with applicable Commonwealth water quality standards.

(3) **Potential Effects on Human Use Characteristic**

(a) **Municipal and Private Water Supply.** There are no water supply intakes within the project area.

(b) **Recreational and Commercial Fisheries.** Not applicable.

(c) **Water Related Recreation.** Not applicable.

(d) **Aesthetics.** During construction there would be a minor decrease in the aesthetics of the area from the presence and operation of heavy equipment.

(e) **Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves.** None.

g. **Determination of Cumulative Effects on the Aquatic Ecosystem.** No cumulative impacts have been identified for this area.

h. **Determination of Secondary Effects on the Aquatic Ecosystem.** Not applicable.

III. **Findings of Compliance or Non-Compliance With the Restrictions on Discharge.**

a. **General:** Section 301 of the Clean Water Act prohibits the discharge of dredged or fill material into waters of the United States unless authorized by the Department of the Army pursuant to Section 404 of the same Act. The wetlands adjacent to the Rio Guanajibo and San José Homes Subdivisions are considered waters of the United States as defined by 33 CFR 328.3(a)(7). The purpose of

Section 404(b)(1) of the Clean Water Act is to restore and maintain the chemical and physical, and biological integrity of the waters of the United States through the control of discharges of dredged or fill material. Controls are established through restrictions placed on the discharges in Guidelines published in 40 CFR 230.

b. **Restrictions on the Discharge:** Section 230.10 requires that the discharge meet certain restrictions in order to be authorized. The project is to be evaluated and comply with the following restrictions: (a) there would be no other practicable alternatives to the proposal that would have less adverse impacts on the aquatic environment, (b) that the discharge would not adversely impact water quality, violate State water quality standards, toxic effluent standards, or jeopardize the continued existence of a threatened or endangered species as identified under the Endangered Species Act, (c) the discharge would not cause or contribute to the significant degradation of waters of the United States, or (d) the project would be designed in such a manner as to minimize to the extent possible the adverse impacts on the aquatic environment.

c. **Initial Evaluation:** An evaluation of the fill material was conducted in accordance with Part 230.61. The impacts are addressed in Section VI and are primarily related to a reduction in biological productivity from the physical displacement of mature mangroves. Since there would be no other practicable alternatives to the proposal, the adverse impacts have been minimized to the extent possible, and no other restrictions have been violated, and, consequently, the proposed work would comply with the restrictions in Section 230.10. In addition, there is no indication that the fill material to be used for the project would be contaminated above background levels. Therefore, the fill material is designated as a Category 5 fill and, in accordance with Part 230.63(a), no testing of chemical-biological interactive affects is required.

d. **Factual Determination:** Based on the probable impacts addressed above, compliance with the restrictions, and all other information concerning the fill materials to be used, the proposed discharge appears to comply with the Guidelines and the intent of Section 404(b)(1) of the Clean Water Act.

TRIP REPORT
 PUERTO RICO WETLANDS DELINEATION
 14-19 JAN 1990
 JAMES W. TEAFORD

1. Background: I responded to a request from the Jacksonville District Office, Planning Division, to identify and delineate wetlands occurring within the Rio Guanajibo (i.e., Mayaguez area), and Rio Loiza (i.e., Caguas area) flood control projects. Dr. Jon Moulding, Jacksonville District, coordinated the trip and accompanied me to Puerto Rico.

2. Personnel. The following people participated in various aspects of this field trip:

Dr. Jon Moulding, Jacksonville District, COE
 Raphael Garcia, Private Consultant (soils)
 Jose Rosario, Regulatory Specialist, San Juan, COE
 Migueal Rodriguez, Planning Group, San Juan, COE
 Felix Lopez, Boqueron, P.R., USFWS
 Dr. Vance Vincente, Boqueron, P.R., USFWS
 Susan Silander, Boqueron, P.R., USFWS
 Dr. George R. Proctor, San Juan, Puerto Rico Dept. Natural Resources

3. Methods: I applied the Federal Interagency wetland identification and delineation concepts and methodology (i.e., the "3 parameter" approach) as outlined in the 1989 Federal Interagency Manual. All identification and delineation determinations were based primarily on an examination of the soils on site, and on an assessment of the dominant plant species occurring on the site. Because my visit occurred during the dry season, I assumed that the hydrology criterion would be satisfied during the rainy season for those sites meeting the hydric soil and hydrophytic vegetation criteria, as long as those sites showed no evidence of significant hydrologic disturbance (see Para.3.36, Federal Interagency Manual).

The wetland determinations that I made on this trip were robust in that I used a small number of representative samples to characterize the larger areas examined. I am confident of the wetland versus non-wetland status of the calls that I made, but the delineation lines between wetlands and non-wetlands on any given site are certainly approximate. It was my understanding that this was the level of detail requested by the Jacksonville District for this stage of their project planning process.

Vegetation. I relied on the assistance of the following individuals to identify and provide scientific names for the dominant plant species occurring on each site.

Susan Silander, Endangered Species Botanist, USFWS, Boqueron, P.R.
 Jose Rosario, Regulatory Specialist, COE, San Juan, P.R.
 Dr. George R. Proctor, Plant Taxonomist, Dept of Natural Resources,
 San Juan, P.R.

Soils. Based on soil series and mapping unit information provided in the Mayaguez area and San Juan area soil survey reports, I developed a field key to the soil series that I expected to find at the various sites. I examined

the soils at each site using a soil probe and shovel, and with the assistance of Mr. Rafael Garcia, retired SCS employee and private consultant, I assigned the soil found at each site to a specific soil series. After examining and recording the appropriate matrix and mottle colors of each sample, I determined whether the soil at that point was hydric or non-hydric based on the field indicators. I especially used this approach in the Rio Guanajibo area where the Coloso soil series was extensively mapped. When I could not identify the series, I relied on field indicators, primarily soil colors, to determine the hydric/non-hydric status of the soil.

Hydrology. Flood frequency and stage data were available for the Rio Guanajibo project (both at San German and at Mayaguez), but these data were not available for the Rio Loiza project. I briefly reviewed this flood frequency and stage data before I visited the sites, but I did not determine the flooding depth for each site before I made my delineation determinations. At all sites, I recorded the presence of hydrologic indicators when they were evident.

The absence of recorded hydrologic indicators on the data sheets does not imply that the hydrology criterion was not met, as it appears that most of the floodplain sites will be subject to flooding by the 2-year flood. The important hydrologic question seems to be whether or not the combination of frequent floods of brief duration, and high precipitation (concentrated in the rainy season) will be adequate to satisfy the hydrology criterion.

Data Sheets. Data sheets and maps showing the location of all sites sampled are attached. Mr. Jose Rosario, Regulatory Specialist, COE, San Juan, recorded the vegetation data for all sites.

4. Rio Guanajibo Project: After visiting 4 sites at San German, and 10 sites at Mayaguez, I made the following general conclusions:

- 1) All areas mapped as Tidal Swamp (Td) are wetlands.
- 2) All areas mapped as Alluvial Lands (An) are wetlands.
- 3) All areas mapped as Bajura (Ba) are wetlands.
- 4) Essentially all areas mapped as Coloso soils (Cn) that are in pasture are wetlands (the exceptions are the inclusions of Toa soils on the ridges within the Coloso delineations).
- 5) Essentially all areas mapped as Coloso soils (Cn) that are actively planted and maintained as sugarcane fields are not currently functioning as wetlands. The management of these sugarcane fields apparently removes enough surface water during the year to keep these areas from meeting the hydrology criterion of wetlands. If, however, the sugarcane farming is stopped and a field reverts to pasture, I believe that field will once again function as a wetland (i.e., a change in land use from agriculture to something else would probably impact wetlands on these sites).

San German Site Summaries

Site 1 (Downstream Pasture). This area is mapped as Toa and Reilly soils. These are classified as non-hydric soils, and field observations confirmed this. This site was designated non-wetland except for a small inclusion of

Coloso soils that was classified as a wetland.

Site 2 (Upstream Pasture). This area appeared to be primarily Reilly soils as mapped, but the area does have an inclusion of what appeared to be a deep mollisol following the drain coming out of the MvC (Monte grande clay) map unit as indicated on the soils map. Both the Reilly soils and the mollic inclusion are non-hydric and the site is classified as non-wetland. There may be a small area of wetlands adjacent to the filled area behind the businesses along the highway; if so, these wet areas result from the disruption of normal drainage patterns caused by the fill materials.

Site 3 (Wooded Park). This area is mapped as Reilly soil and is predominately non-wetland. There are, however, some small areas of wetlands in the lowest portions of the drains running through the area.

Site 4 (Subdivision Pasture). This area is mapped as Reilly soils and appeared to be predominantly non-wetland. There is one area that may be wetland (i.e., the area immediately at the toe of the slope of the hill on the south side of the floodplain), but we could not confirm or refute this as we were not able to cross the fence to examine the area. It appears that the roadfill at the toe of this slope may be blocking the natural drainage to the Rio Guanajibo.

Mayaguez Site Summaries

Site 1 (Mouth of the Rio Guanajibo). This area is mapped as Bajura and Coloso soils. The Bajura soil and the plant community growing on it are clearly wetland. The Coloso soil is occupied by an abandoned sugarcane field that is growing up to paragrass (*Bracharia gurgurascens*-FACW) and guineagrass (*Panicum maximum*-FACU). According to Mr. Garcia, the paragrass is being suppressed and the guineagrass is becoming more dominant due to selective grazing by cattle in the area (i.e., the cattle apparently prefer to graze on paragrass rather than guineagrass). Based primarily on soil colors, I believe that this sample of Coloso soil is hydric and that the area is a wetland.

Site 2 (K Mart Pasture). This area is mapped as Coloso soils, but when we examined them in the field, they appeared to be buried by recent sediments from the upper part of the watershed (i.e., within the last 20-30 years). The matrix colors were 10YR 4/2 to 4/3 and redder, with mottles of 10 YR 5/2 and 7.5 YR 4/6. The red mottles are very prominent and the soils have Fe accumulations along old root channels, as if to indicate periods of significant reduction and movement of Fe. In spite of the red soils, I believe that these areas are wetlands.

Site 3 (Farmhouse-West Pasture). This area is mapped as Coloso soils and 3 of 4 soil samples had low matrix chromas with mottles. The soil appeared to be the Coloso series, and I classified the site as a wetland.

Site 4 (Filled Area at the Mouth of the Rio Guanajibo). This area is mapped as Leveled Sandy Land and appears to be a filled area. The area is predominantly non-wetland, with a few, very small, scattered, low, wet spots that would qualify as wetlands. These wet spots can be easily recognized on the ground by the plants growing on them (i.e., giant flatsedge, leather fern, etc.).

Site 5 (Farmhouse-North Pasture). This area is mapped as Coloso, and appeared to be primarily Coloso with some inclusions of Bajura in the lower spots. The

entire site appears to be a wetland.

Site 6 (Farmhouse-South Pasture). This majority of this area appears to be Coloso soils as mapped. There is a small inclusion of Toa soil on a slight ridge that runs generally NW-SE. The area of Coloso soil is wetland and the ridge of Toa soil is non-wetland.

Site 7 (Sugar Mill Pasture). This area is mapped as Coloso, and appears to be primarily Coloso with some inclusions of Toa on the low ridge. The areas of Coloso are wetlands, and the ridge of Toa is non-wetland.

Site 8 (Sugar Mill Canefield). This area is mapped as Mani, but it shows up on the aerial photograph as a possible wet inclusion. From field data, it appears that this spot is an inclusion of the Coloso soil within a Mani (Mn) mapping unit. As the fill is 20-30" deep and the site does not appear to be functioning as a wetland, I classified the site as non-wetland.

Site 9 (Filled Lares Site). This area is mapped as the Lares soil series (non-hydric), but the site appears to be filled with dumped materials. The entire area mapped as Lares is non-wetland.

Site 10 (Lares Site-Abandoned Sugarcane Field). This area is mapped as Lares and Coloso soils. The area that I saw was an area of Coloso soil that had been buried by 6-10" of recent red sediments from the upper watershed. Although the upper layer of recent sediments were too high in chroma for typical hydric soil conditions, the entire area is very clearly a wetland.

5. Rio Loiza Project: I sampled 14 sites in the Caguas area. My results are summarized as follows.

Site 1 (Rio Biarco-African Tuliptree/Dashean Patch). This area is mapped as the Estacion series, but the spot I sampled apparently is not Estacion as it is not a gravelly clay. This soil may have been an inclusion of the Dique series (Fluventic Eutropept). The area is a non-wetland based on soils and vegetation.

Site 2 (Rio Biarco-Pasture Adjacent to Creek). This soils in this area are mapped as the Estacion series, but the matrix color at 10-12" below the surface appears too high for the series (i.e., 10YR 4/4). The area is non-wetland.

Site 3 (Rio Biarco-Overgrazed Pasture/Leyas). This area is mapped as the Estacion series and appeared to be the series as mapped. The area is non-wetland based on soils.

Site 4 (Rio Biarco-Rain). This site is mapped as Mabi clay. I was not able to determine the series, but the chroma is too high for a hydric soil and the area is non-wetland.

Site 5 (Rio Biarco-Perched Wetland/Dashean Swale/River Terrace). The terrace and swale are mapped as Estacion, while the perched area is mapped as Mabi. The soils of the terrace appear to be the Estacion series and the terrace is non-wetland. The soils of the swale appear to be from the Bajura series, and the swale is a wetland. The soils on the ridge ranged from a 10 YR 4/2 matrix to a variegated mix of 10 YR 4/2-4/3, 10 YR 6/1, and 2.5 YR 4/6-4/8.

(these colors were estimated from memory). I classified this ridge as a wetland based on the soils, vegetation, and apparent hydrology.

Mr. Garcia had a conversation with an elderly gentleman who apparently has lived in the area for approximately 70 years. According to this gentleman, the site has been wet for as long as he can remember, and has not been filled. It appears that the soils on this ridge may be underlain by a relatively impermeable layer (plinthite ?) that acts as a conduit to bring groundwater to the surface as a source of hydrology. If this area is critical to the planning process, it should probably be investigated further.

Site 6 (Pony Pasture). This area is mapped as a Mabi clay (a non-hydric soil), but the soil probe samples that I examined did not agree in color with the series description. I looked at 3 representative samples and all 3 indicated that the soil is hydric. The Mabi series is classified as somewhat poorly drained and it may be that this site is one of the wetter examples of the series. Based on the soils, vegetation, and hydrology, this site is a wetland.

Site 7 (Red Tow Truck Site). This site is mapped as Estacion and appears to be the series as mapped. The chroma is too high for the soil to be hydric, and the vegetation is not predominately hydrophytic. This site is non-wetland.

Site 8 (Farm Pond Pasture). This area is mapped as the Toa series. Most of the area appears to be Toa, and thus non-wetland. There is an apparent inclusion of the Coloso(?) series on the site in and around the farm pond. The farm pond and a 25-50 foot transition zone around the pond are wetlands.

Site 9 (Pasture Adjacent to and Upstream from Site 8). This site is mapped as Mabi clay, but the soil sample on site yielded a sandy loam, and I am not sure just what the actual series is. The matrix chroma is 10YR 4/4 which makes the soil non-hydric, and the vegetation is dominated by non-hydrophytic plants. The entire area is non-wetland.

Site 10 (Bull Pasture). This site is mapped as the non-hydric Toa series. Although I did not verify the mapping (i.e., by probing below the mollic epipedon and reading the subsoil colors), Mr. Garcia was satisfied that the soil was indeed Toa. The area is a non-wetland based on the non-hydric soil.

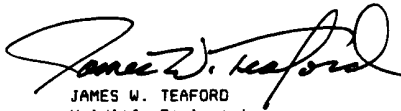
Site 11 (Overlook Wetland). This area is mapped as Estacion and Mabi. I believe the soils that I sampled are actually Estacion, based on the gravelly subsoil. The soil is non-hydric, and the majority of the area is non-wetland. There are 2 small wetland areas on the site, based on soil colors (matrix chroma of 5B/Y 4/1) and vegetation (Dasheen plants). Jon Moulding is aware of the location of these 2 spots (one is on the terrace below the basketball court at the base of the newly filled area, and the other is on the terrace below the deadend street where the lady showed us the photographs of the area under flood conditions).

Site 12 (Ponded Swale). This area is mapped as Estacion, Rio Arriba, and Toa soils. The lower 100-150 yards of the swale have hydric soils and hydrophytic vegetation, and are wetlands. The upper portion of the swale has positive field indicators for hydric soils, but the vegetation is dominated by non-hydrophytic plants, and this area is a non-wetland. The terrace has non-hydric soils and non-hydrophytic vegetation, and is a non-wetland.

Site 13 (Cattle Tunnel Pasture). This area is mapped as the Dique series on

the lower terrace, and as the Toa series on the upper terrace. Both series are considered non-hydric and the field indicators support this. Most, if not all, of the area is non-wetland. There is a small swale that may be an inclusion of the Coloso series at the base of the upper terrace where it adjoins the lower terrace, but the matrix chroma appears to be too high for a hydric soil and I believe the swale is also a non-wetland.

Site 14 (School Pasture). We visited the site right at sunset and the light was so low that I could not read the soil colors. I made several attempts to take soil cores with the probe, but I hit a gravelly layer at 6-8" each time. The presence of this gravelly subsoil seems to verify that the soil is indeed the non-hydric Estacion series as mapped. The site is non-wetland based on soils and vegetation.



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MISCELLANEOUS PAPER EL-89-__

EVALUATION OF WETLAND FUNCTIONS AND VALUES

AT MAYAGUEZ AND ARECIBO, PUERTO RICO

by

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DEPARTMENT OF THE ARMY

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Final Report

Prepared for US Army Engineer District, Jacksonville
Jacksonville, FL 32232-0019

PREFACE

This study was conducted at the request of the US Army Engineer District, Jacksonville (CESAJ) by members of the Wetlands Research Team (WRT), Wetlands and Terrestrial Habitat Group (WTHG), Environmental Resources Division (ERD), Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES).

Wetland evaluations were conducted by Mr. R. Daniel Smith, WTHG. Technical support and assistance were provided by Drs. Hanley K. Smith and John Moulding, Planning Division, CESAJ, and Messrs. Juan Martinez and Roberto Cortes, Puerto Rico Field Office, CESAJ. The project was conducted under the technical supervision of Mr. Ellis J. Clairain, Jr., Team Leader, WRT and under the general supervision of Mr. E. Carl Brown, Chief, WTHG; Dr. Conrad J. Kirby, Jr., Chief, ERD; and Dr. John Harrison, Chief, EL.

Commander and Director of WES was COL Larry B. Fulton, EN. Technical Director was Dr. Robert W. Whalin.

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EVALUATION OF WETLAND FUNCTIONS AND VALUES
AT MAYAGUEZ AND ARECIBO, PUERTO RICO

PART I: INTRODUCTION

Background

1. On 30 January 1989 the Jacksonville District requested assistance from the Wetlands Research Team (WRT), of the Environmental Laboratory, US Army Engineer Waterways Experiment Station, to evaluate wetlands at several proposed construction project sites in Puerto Rico. In response to this request, Mr. R. Daniel Smith of the WRT traveled to Puerto Rico and conducted field evaluations of eight wetlands during the week of 13 February 1989.

2. This report outlines the methods used during this project, provides descriptions of the wetland sites that were evaluated, and summarizes the results of the evaluation.

Methods

Wetland Evaluation Technique

3. Wetland evaluations in this project were conducted using the Wetland Evaluation Technique, Version 2.0 (WET) (Adamus et al, 1987). WET is an assessment technique designed for quickly obtaining an initial functional profile for a wetland. The technique is intended to meet the relatively specific needs of planners, managers, regulators, and others in the Government and private sectors who, because of regulatory mandate or permitting specifications, are required to evaluate wetland functions and values with limited time and resources. The functions assessed by WET include:

- Ground water recharge
- Ground water discharge
- Floodflow alteration
- Sediment stabilization
- Sediment/toxicant retention
- Nutrient removal/transformation
- Production export
- Wildlife habitat
- Fisheries habitat
- Uniqueness/heritage
- Recreation

4. The WET assesses functions and values of a wetland assessment area (AA) by characterizing the physical, chemical, and biological attributes and processes of the AA. The characterization is accomplished by answering a series of questions about the AA. For example, What is the size of the AA watershed? and What is the frequency of inundation in the AA? Responses to the questions are analyzed in function-specific interpretation keys based on the relationship between wetland attributes and process and wetland functions

as defined in the technical literature. The analysis results in the assignment of a probability rating of HIGH, MODERATE, or LOW to each function or value.

5. The WET evaluates wetland functions and values in terms of social significance and effectiveness and opportunity. Social significance assesses the actual, or potential, benefits society derives from the wetland. These benefits are established using several criteria. One criteria is whether the wetland is strategically located in relation to people and/or the objects of economic value to people. If a wetland is strategically located, there is a greater probability that the functions it performs will directly benefit society. For example, the wetland upstream from a town that is performing the floodflow alteration function will have a greater probability of being socially significant than the wetland that is performing the floodflow alteration function but is located in an area where no economic development exists downstream.

6. A second criterion for assessing social significance is whether the wetland is used for recreational, educational, or cultural activities. A third criterion considers whether the wetland has been given special status or significance by society. For example, the area is designated as wildlife refuge, national park, etc., the area is archaeologically significant, or the area supports endangered species.

7. Effectiveness assesses the capability of a wetland to perform a particular wetland function based on the biological, physical, and chemical attributes of the wetland and processes that take place in the wetland. Opportunity assesses whether the wetland has the opportunity to perform to its fullest level of capability.

8. The effectiveness and opportunity portion of the evaluation consists of three levels. Each level consists of a series of question designed to characterize the wetland and its surroundings in terms of physical, chemical, and biological attributes and processes. Successive levels of evaluation build on previous levels to develop an increasingly detailed characterization of the wetland. Corresponding to the increasingly detailed characterization is an increased confidence in the probability ratings that result from the evaluation. The level of evaluation chosen depends upon the time and information available, as well as the confidence desired. In many cases the physical and chemical data required are not available for the wetland site. Our experience has shown that WET evaluations which include the first and second levels of the effectiveness and opportunity evaluation provide an acceptable balance between these three factors for most evaluation situations.

9. The WET assesses functions and values for a specified wetland assessment area (AA). Boundaries for the AA are based on hydrology, geomorphology, and other topographic criteria. In some cases, the AA includes all wetlands at a particular site. In other cases, two or more AA's can be identified and must be evaluated because of hydrologic isolation or significant differences in hydrologic regimes, hydroperiods, or other factors that may cause two wetland areas to be functionally different.

Preliminary data gathering

10. Preliminary data gathering was completed prior to traveling to Puerto Rico. The Jacksonville District cooperated by providing much of the necessary information, including aerial photography, topographic maps, soil surveys, project plans, and other maps and documents covering the Arecibo and Mayaguez regions of Puerto Rico.

Site reconnaissance and selection

11. The study focused on two proposed construction project sites in Puerto Rico. The first proposed project site is located near the town of Mayaguez and involves levee construction and channel improvement on the floodplain of the Rio Guanajibo and some of its tributaries (Figure 1). The second construction project site is located near the city of Arecibo and involves seawall construction, levee construction, channel improvements, and channel diversion on the floodplain of the Rio Grande Arecibo and some of its tributaries (Figure 2).

12. Initial field reconnaissance of the areas was conducted by representatives from the WRT, the Jacksonville District, and the Puerto Rico Field Office. Eight sites were selected for evaluation. These were selected because they were representative of the wetland types that occurred in the proposed construction project areas and because they were the wetland areas most likely to be impacted by proposed construction projects due to their proximity to the projects.

13. Five sites were selected for evaluation at the Guanajibo project site near Mayaguez, Puerto Rico. These sites were given the following names:

Guanajibo Homes
Cano Corazones
Cano Majagual
Merle Marsh
Rio Guanajibo Floodplain

14. Three sites were selected for evaluation at the Rio Grande Arecibo project site near Arecibo, Puerto Rico. These sites were given the following names:

Mouth of Rio Grande Arecibo
Arecibo Marsh
Rio Santiago

15. Following the initial field reconnaissance the WRT made a second field visit to each of the evaluation sites to conduct the evaluation. In the following section, a site description is given for each AA along with results of the WET evaluation and a discussion of the probable impact of the proposed project on the functions and values of the wetland.

PART II: EVALUATION OF WETLAND FUNCTIONS AND VALUES

Guanajibo Homes Assessment AreaSite description

16. The AA is located east of Highway 103 between the mouth of Rio Guanajibo and Cano Corazones, approximately 3 km south of the city limits of Mayaguez, Puerto Rico. The AA lies south and east of the residential development known as "Guanajibo Homes." Figure 3 shows the boundaries of the AA and its relationship to features in the surrounding area.

17. The AA is mapped by the National Wetland Inventory (NWI) as estuarine, intertidal, forested, broad-leaved evergreen wetland (E2F03). The northern three-fourths of the AA is a mature, wetland forest dominated by black mangrove. This area is irregularly flooded by tides (i.e., tidal waters flood the land surface less than once daily). Along the north and east boundary of the AA a low ridge (beginning at the northeast corner of the residential area) separates the AA from Cano Corazones. This ridge, which appears to have been built up with fill material several years ago, limits tidal inundation of the AA. Prior to the existence of this ridge, portions of the AA were probably subject to daily tidal inundation. During field visits to this area the soil surface exhibited numerous cracks caused by drying of the soil surface.

18. The southern one-fourth of the AA is a more diverse wetland forest dominated by *Pterocarpus* (*Pterocarpus officinalis*), red mangrove (*Rhizophora mangle*), white mangrove (*Languncularia racemosa*), royal palm (*Roystonea borinquena*), and leather fern (*Achrostichum* spp.). This portion of the AA is also irregularly flooded by tides. During field visits to this area the soil was saturated at the surface, but standing water was not present. The saturated soil in the southern portion of the AA may indicate a lower elevation in this portion of the AA, which is unlikely given the plant species composition, or more likely a higher water table due to proximity to Rio Guanajibo. Both the northern and southern portions of the AA receive fresh water from precipitation and overbank flooding from the Guanajibo River. Soils in the AA are mapped as the hydric Bajura Series (Ba) or Tidal Swamp (Td).

Results

19. Results of the WET evaluation for the Guanajibo Homes AA are shown in Table 1. WET Field Data forms A, B, C, and D for this AA are given in Appendix A.

Project impact on wetland functions and values

20. The proposed construction plans indicate the residential area of Guanajibo Homes is to be protected with a ring levee (Figure 1). There is a potential for both long- and short-term impacts on the functions and values of the wetland as a result of these plans. In the long term, because of the proximity of the wetland to the residential area, the space required by the

levees and associated ditch and buffers will probably result in a loss of a small amount of wetland acreage. Nevertheless, the loss of wetland acreage will result in the concomitant loss of wetland functions and values.

21. In the short term, there is the potential of direct impact to the wetland during the construction process through the introduction of sediments (via erosion), disruption of surface hydrology, physical disturbance, etc. However, these impacts can be reduced, or eliminated, through the judicious use of sediment fences and other practices designed to minimize the impact of the construction process on the adjacent wetland.

Cano Corazones Assessment Area

Site description

22. The AA is located east of Highway 103 on the north side of Cano Corazones (with the exception of a narrow fringe along the south side of Cano Corazones) approximately 2.5 km south of the city limits of Mayaguez, Puerto Rico. The AA lies south and east of the residential area known as "San Jose." Figure 5 shows the boundaries of the AA and its relationship to features in the surrounding area.

23. This AA is mapped by the NWI as an estuarine, intertidal, forested, broad-leaved evergreen wetland (E2F03). The AA is a mangrove forest with red, black and white mangrove present. Much of the area is regularly flooded by tides (i.e., tidal water floods the land surface at least once daily); the remainder is irregularly flooded. A large portion of the area was flooded with several inches of water during the field visit.

24. There is an intermittent (possibly permanent) inflow of fresh water to the AA in at least two locations along the eastern boundary of the AA. These inflows originate from Cano Merle to the northeast and a drainage ditch originating in Merle Marsh to the northeast. The inflows are shown on the map in Figure 5. The AA also receives fresh water from precipitation and has the potential to be inundated with fresh water when overbank flooding occurs on Cano Merle and the Guanajibo River. Soils in the AA are mapped as Tidal Swamp (Td).

Results

25. Results of the WET evaluation for the Cano Corazones AA are shown in Table 2. WET Field Data Forms A, B, C, and D for this AA are given in Appendix A.

Project impact on wetland functions and values

26. The proposed construction plans indicate that the residential area of Guanajibo Homes is to be protected with a ring levee (Figure 1). There is a potential for both long- and short-term impacts on the functions and values of the wetland as a result of these plans. In the long term, because of the proximity of the wetland to the residential area, the space required by the

levee and associated ditch and buffers will probably result in a loss of a small amount of wetland acreage. Nevertheless, the loss of wetland acreage will result in the concomitant loss of wetland functions and values.

27. The proposed construction plans indicate that the residential/commercial area of San Jose will be protected by a levee (Figure 1). There is a potential for both long- and short-term impacts to the functions and values of the wetland as a result of these plans. In the long term, the physical space required for the levee and ditch may cause the loss of wetland acreage. The existing buffer between the wetland and developed area appears to be adequate to accommodate the levee and ditch without the loss of wetland acreage. Impact due to loss of wetland acreage will be more likely along the northeast boundary of the wetland where the proposed levee placement will result in the loss of mangrove wetland acreage. Any loss of wetland acreage will result in a concomitant loss of wetland functions and values.

28. In addition to the potential loss of acreage, levee construction may result in the loss of the hydrologic link between Merle Marsh/Cano Merle and Cano Corazones. Disruption of this link could impact the freshwater-saltwater balance in Cano Corazones and have long-term effects on the functions and values of the Cano Corazones wetland. It may be possible to preserve the hydrologic link between Merle Marsh/Cano Merle and Cano Corazones using culverts, or other structural measures.

29. In the short term, there is the potential of direct impact to the wetland during the construction process through the introduction of sediments (via erosion), disruption of hydrology, physical disturbance, etc. However, these impacts can be reduced, or eliminated, through the judicious use of sediment fences and other practices designed to minimize the impact of the construction process on the adjacent wetland.

Cano Majagual Assessment Area

Site description

30. The AA is located east of Highway 103, and southwest of the confluence of Cano Majagual and Cano Merle approximately 1 km south of the city limits of Mayaguez, Puerto Rico. Figure 7 shows the boundaries of the AA and its relationship to features in the surrounding area.

31. The AA is mapped by the NWI as a estuarine, intertidal, forested, broad-leaved evergreen wetland (E2F03). The AA is a mangrove forest subject to irregular flooding by tides. The AA receives fresh water from precipitation and seasonal overbank flooding from Cano Majagual, Cano Merle, Quebrada Sabalos, and Rio Guanajibo. Soils in the AA are mapped as Tidal Swamp (Td).

Results

32. Results of the WET evaluation results for the Cano Majagual AA are shown in Table 3. WET Field Data Forms A, B, C, and D for this AA are given in Appendix A.

Project impact on wetland functions and values

33. The proposed construction plans indicate that a levee will be placed south of the AA (Figure 1). There is a potential for both long- and short-term impacts to the functions and values of the wetland as a result of these plans. In the long term, the space required for the levee and associated ditches/buffers may cause the loss of wetland acreage. However, because of the distance separating the wetland from the proposed construction, the loss of wetland acreage is unlikely.

34. Another impact of the proposed construction on the functions and values of the wetland will result from cutting off the wetland from overbank flooding on the Rio Guanajibo. However, since the primary source of freshwater input to the wetland (Rio Majagual and Cano Merle) will remain intact, it is difficult to determine if the loss of freshwater inflow from the overbank flooding of Rio Guanajibo will be significant to the maintenance of wetland functions and values.

35. In the short term, there is the potential of direct impact to the wetland during the construction process through the introduction of sediments (via erosion), disruption of hydrology, physical disturbance, etc. However, these impacts can be reduced, or eliminated, through the judicious use of sediment fences and other practices designed to minimize the impact of the construction process on the adjacent wetland.

Merle Marsh Assessment Area

Site description

36. The AA is located west of Highway 2 approximately 2 km south of the city limits of Mayaguez. Cano Merle runs through the middle of the marsh. Figure 9 shows the boundaries of the AA and its relationship to features in the surrounding area.

37. The AA is mapped by the NWI as a palustrine, emergent, persistent wetland (PEM1). The AA is a freshwater marsh dominated by cattails and giant sedge along with various other emergent species. At the time of the site, visit the marsh soil was saturated to the surface, but standing water was not present. Surface water is undoubtedly present when precipitation causes flooding in the Cano Merle watershed. Soils in the AA are mapped as the hydric Bajura Series (Ba) and Alluvial land (An).

Results

38. Results of the WET evaluation for the Merle Marsh AA are shown in Table 4. WET Field Data Forms A, B, C, and D for this AA are given in Appendix A.

Project impact on wetland functions and values

39. The proposed construction plans indicate that a levee will be placed along the west boundary of the AA (Figure 1). In addition, Cano Merle will undergo channel improvements downstream from Highway 114 (Figure 1). There is a potential for both long- and short-term impacts on the functions and values of the wetland as a result of the proposed project. In the long term, the space required for the levee, associated ditches/buffers, and channel improvements may result in the loss of wetland acreage due to the proximity of the wetland to the proposed construction. The loss of wetland acreage will result in a concomitant loss of wetland functions and values.

40. In addition, channel improvement may have a significant effect on the present functions and values of the wetland. Presently, surface water enters Merle Marsh via Cano Merle. In Merle Marsh, Cano Merle is a narrow ditch clogged with emergent and floating-leaved wetland species. Surface water is detained in Merle Marsh because the water velocity decreases and spreads over the marsh. This situation allows the wetland to provide water quality functions through the retention of sediments, nutrients, and contaminants. Channel improvements will alter the present situation by decreasing the time required for surface water to pass through the wetland system.

41. The most significant long-term impact to the functions and values of Merle Marsh may be the loss of wetland acreage due to the placement of fill material subsequent to levee construction. There will be tremendous pressure to develop the flood protected wetland areas behind the levee such as Merle Marsh.

42. In the short term, there is the potential of direct impact to the wetland during the construction process through the introduction of sediments (via erosion), disruption of hydrology, physical disturbance, etc. However, these impacts can be reduced, or eliminated, through the judicious use of sediment fences and other practices designed to minimize the impact of the construction process on the adjacent wetland.

Guanajibo Floodplain Assessment Area

Site description

43. The AA is located downstream of the Highway 114 bridge at the point where it crosses the Rio Guanajibo approximately 4.5 km south of the city limits of Mayaguez. Figure 11 shows the boundaries of the AA and its relationship to features in the surrounding area.

44. This AA is mapped by the NWI as a palustrine, emergent, persistent, farmed wetland (PEM1f). The AA consists primarily of sugar cane fields (north

of river) and pasture (south of river), which is typical of much of the Rio Guanajibo floodplain. The AA is inundated seasonally by overbank flooding from the Rio Guanajibo.

45. Soils in the AA are in the Toa (ToA), Coloso (Cn), Mani (Mn), Reilly (Re), and Dique (Du) Series. Soils in the AA are not on the hydric soils list of the United States (USDA 1987); however, they may be considered jurisdictional in some circumstances according to Corps regulatory personnel in Puerto Rico (Juan Mendina, personal communication).

Results

46. Results of the WET evaluation for the Guanajibo Floodplain AA are shown in Table 5. WET Field Data Forms A, B, C, and D for this AA are given in Appendix A.

Project impact on wetland functions and values

47. The proposed construction plans indicate that a levee will be placed along the western boundary of the AA (Figure 1). There is a potential for both long and short term impacts on the functions and values of the wetland as a result of the proposed project. In the long term, the space required for the levee and associated ditches/buffers may result in the loss of wetland acreage due to the proximity of the wetland to the proposed construction. The loss of wetland acreage will result in a concomitant loss of wetland functions and values.

48. In the short term, there is the potential of direct impact to the wetland during the construction process through the introduction of sediments (via erosion), disruption of hydrology, physical disturbance, etc. However, these impacts can be reduced, or eliminated, through the judicious use of sediment fences and other practices designed to minimize the impact of the construction process on the adjacent wetland.

Mouth of Rio Arecibo Assessment Area

Site description

49. This AA is located at the mouth of Rio Grande De Arecibo, downstream of the Highway 2 bridge, and just east of the town of Arecibo. Figure 13 shows the boundaries of the AA and its relationship to features in the surrounding area.

50. This AA is mapped by the NWI as a palustrine, emergent, persistent wetland (PEM1); estuarine, emergent, persistent wetland (E2EM1); and estuarine, scrub-shrub, broad-leaved evergreen wetland (E2SS3). The vegetation and topography in the AA reflect a great degree of disturbance. The portion of the AA west of the main channel of Rio Arecibo is dominated by sugar cane although active cultivation appears to have ceased as is evident by the trees and shrubs that are beginning to appear. The area east of the main channel of Rio Arecibo is dominated by a mixture of trees, shrubs, and grasses

adapted to colonizing disturbed areas. The surface of the ground is uneven, as if disturbed in the past with heavy equipment. The small mangrove forest in the northeast corner of the AA is the only area that seems to have escaped recent disturbance.

51. The majority of the AA is irregularly flooded by the tide and by fresh water when overbank flooding occurs on Rio Arecibo. A small area of mangroves at the northeast corner of the AA is regularly, if not permanently flooded. During the site visit, surface water was present in this area. Soils in the AA are in the hydric Bajura (Ba) and nonhydric Coloso (Cn) Series.

Results

52. Results of the WET evaluation for the Mouth of Rio Arecibo AA are shown in Table 6. WET Field Data Forms A, B, C, and D for this AA are given in Appendix A.

Project impact on wetland functions and values

53. The proposed construction plans indicate the construction of a seawall/levee to protect the town of Arecibo (Figure 2). There is a potential for both long- and short-term impacts to the functions and values of the wetland. Because of the proximity of the town of Arecibo to the wetland, the space required to construct the levee and associated ditches/buffers will probably result in the loss of wetland acreage. The loss of wetland acreage will result in the concomitant loss of wetland functions and values.

54. In the short term, there is the potential of direct impact to the wetland during the construction process through the introduction of sediments (via erosion), disruption of hydrology, physical disturbance, etc. However, these impacts can be reduced, or eliminated, through the judicious use of sediment fences and other practices designed to minimize the impact of the construction process on the adjacent wetland.

Arecibo Marsh Assessment Area

Site description

55. This AA is located in the center of the town of Arecibo south and west of Avenue Luis Llorens Torres. Figure 15 shows the boundaries of the AA and its relationship to features in the surrounding area.

56. This AA is mapped by the NWI as a palustrine, emergent, persistent wetland (PEM1). The AA is a freshwater, emergent wetland dominated by cattail and giant sedge in conjunction with a variety of other emergents. The AA is surrounded by residential and commercial development on the adjacent upland. A small levee forms the eastern boundary of the AA and protects the Escuela M Cadilla during flooding. Rio Santiago functions as the southern boundary of the AA. Soils in the AA are mapped as Urban (Ur). Field inspection revealed them to have a profile like the hydric Bajura Series (Ba).

Results

57. Results of the WET evaluation for the Arecibo Marsh AA are shown in Table 7. WET Field Data Forms A, B, C, and D for this AA are given in Appendix A.

Project impact on wetland functions and values

58. No construction is planned in the vicinity of the Arecibo Marsh AA as part of the proposed construction project (Figure 2). However, water that is presently carried to the town of Arecibo by Rio Santiago will be diverted at a point south of the town of Arecibo to the main channel of Rio Arecibo. Presently, when Rio Arecibo and Rio Tanama flood, the floodwater is carried by Rio Santiago into the town of Arecibo. Arecibo Marsh functions as a detention basin during these flood events. The primary effect of diverting water from Rio Santiago will be to reduce the quantity of floodwater being carried into the town of Arecibo by Rio Santiago.

59. The proposed diversion is likely to have little, if any, impact on the functions and values of Arecibo Marsh. The hydrologic regime of Arecibo Marsh will be maintained by existing surface water and ground water inflows without being supplemented by overbank flooding from Rio Santiago (which is a concrete-lined ditch in the vicinity of Arecibo Marsh).

Rio Santiago Assessment Area

Site description

60. This AA is located in the southern part of the town of Arecibo. The AA is that portion of Rio Santiago between Avenue Constitucion and the southern city limits of Arecibo. Figure 17 shows the boundaries of the AA and its relationship to features in the surrounding area.

61. This AA is mapped by the NWI as riverine, lower perennial, aquatic bed (R2AB). This reach of Rio Santiago (like the majority of Rio Santiago) is a large drainage ditch with eroding sideslopes. Along the sides and bottom of the ditch, emergent and floating-leaved vascular vegetation occurs. Soils adjacent to the AA are in the Coloso Series (Cn).

Results

62. Results of the WET evaluation for the Rio Santiago AA are shown in Table 8. WET Field Data Forms A, B, C, and D for this AA are given in Appendix A.

Project impact on wetland functions and values

63. Proposed construction plans for this portion of Rio Santiago are restricted to channel improvements (Figure 2). The proposed construction project has a potential for long-term impacts to the functions and values of the wetland. Channel improvements will result in a loss of some wetland

acreage. The loss of wetland acreage will result in the concomitant loss of wetland functions and values.

64. Surface water presently carried to the town of Arecibo by Rio Santiago will be diverted to the main channel of Rio Arecibo at a point south of the town of Arecibo (Figure 2). Presently, when Rio Arecibo and Rio Tanama flood, floodwater is carried by Rio Santiago into the town of Arecibo. The primary effect of diverting water from Rio Santiago will be to reduce the quantity of floodwater being carried into the town of Arecibo by Rio Santiago.

65. The proposed diversion is likely to have little, if any, impact on the functions and values of the Rio Santiago wetland. The hydrologic regime of Rio Santiago will be maintained by existing surface water and ground water inflows without being supplemented by overbank flooding from Rio Arecibo and Rio Tanama.

REFERENCES

- Adamus, P. R., Clairain, E. J., Jr., Smith, R. D., and Young, R. E. 1987. "Wetland Evaluation Technique (WET) - Version 2.0; Volume II: Methodology," Operational Draft Technical Report, Y-87-__, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- USDA, Soil Conservation Service. 1987. "Hydric Soils of the United States. prepared in cooperation with the National Technical Committee for Hydric Soils.

Table 1. WET Results for Guanajibo Home Assessment Area

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	M	L	*
Ground Water Discharge	M	L	*
Floodflow Alteration	M	L	
Sediment Stabilization	H	M	*
Sediment/Toxicant Retention	M	H	M
Nutrient Removal/Transformation	M	L	M
Production Export	*	M	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	M	*
Wildlife D/A Migration	*	L	*
Wildlife D/A Wintering	*	H	*
Aquatic Diversity/Abundance	H	M	*
Uniqueness/Heritage	H	*	*
Recreation	M	*	*

Note: "H" - HIGH, "M" - MODERATE, "L" - LOW, "U" - UNCERTAIN, and "*" identifies conditions in which WET does not evaluate functions and values.

Table 2. WET Results for Cano Corazones Assessment Area

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	M	L	*
Ground Water Discharge	M	L	*
Floodflow Alteration	M	L	L
Sediment Stabilization	H	M	*
Sediment/Toxicant Retention	M	M	M
Nutrient Removal/Transformation	M	L	M
Production Export	*	M	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	M	*
Wildlife D/A Migration	*	L	*
Wildlife D/A Wintering	*	H	*
Aquatic Diversity/Abundance	H	M	*
Uniqueness/Heritage	H	*	*
Recreation	H	*	*

Note: "H" - HIGH, "M" - MODERATE, "L" - LOW, "U" - UNCERTAIN, and "*" identifies conditions in which WET does not evaluate functions and values.

Table 3. WET Results for Cano Majagual Assessment Area.

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	M	L	*
Ground Water Discharge	M	L	*
Floodflow Alteration	M	L	L
Sediment Stabilization	M	M	*
Sediment/Toxicant Retention	M	H	M
Nutrient Removal/Transformation	M	H	H
Production Export	*	M	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	M	*
Wildlife D/A Migration	*	H	*
Wildlife D/A Wintering	*	H	*
Aquatic Diversity/Abundance	H	M	*
Uniqueness/Heritage	H	*	*
Recreation	M	*	*

Note: "H" - HIGH, "M" - MODERATE, "L" - LOW, "U" - UNCERTAIN, and "*" identifies conditions in which WET does not evaluate functions and values.

Table 4. WET Results for Merle Marsh Assessment Area.

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	M	L	*
Ground Water Discharge	M	M	*
Floodflow Alteration	H	M	H
Sediment Stabilization	H	H	*
Sediment/Toxicant Retention	M	H	H
Nutrient Removal/Transformation	M	H	M
Production Export	*	M	*
Wildlife Diversity/Abundance	M	*	*
Wildlife D/A Breeding	*	H	*
Wildlife D/A Migration	*	L	*
Wildlife D/A Wintering	*	H	*
Aquatic Diversity/Abundance	M	M	*
Uniqueness/Heritage	H	*	*
Recreation	L	*	*

Note: "H" - HIGH, "M" - MODERATE, "L" - LOW, "U" - UNCERTAIN, and "*" identifies conditions in which WET does not evaluate functions and values.

Table 5. WET Results for Guanajibo Floodplain Assessment Area.

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	U	L	*
Ground Water Discharge	L	M	*
Floodflow Alteration	M	M	M
Sediment Stabilization	L	H	*
Sediment/Toxicant Retention	L	H	H
Nutrient Removal/Transformation	L	L	M
Production Export	*	M	*
Wildlife Diversity/Abundance	L	*	*
Wildlife D/A Breeding	*	L	*
Wildlife D/A Migration	*	L	*
Wildlife D/A Wintering	*	M	*
Aquatic Diversity/Abundance	L	L	*
Uniqueness/Heritage	L	*	*
Recreation	L	*	*

Note: "H" = HIGH, "M" = MODERATE, "L" = LOW, "U" = UNCERTAIN, and "*" identifies conditions in which WET does not evaluate functions and values.

Table 6. WET Results for Mouth of Rio Arecibo Assessment Area.

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	M	L	*
Ground Water Discharge	M	L	*
Floodflow Alteration	M	L	L
Sediment Stabilization	M	M	*
Sediment/Toxicant Retention	M	L	H
Nutrient Removal/Transformation	M	H	M
Production Export	*	M	*
Wildlife Diversity/Abundance	M	*	*
Wildlife D/A Breeding	*	M	*
Wildlife D/A Migration	*	H	*
Wildlife D/A Wintering	*	H	*
Aquatic Diversity/Abundance	M	M	*
Uniqueness/Heritage	M	*	*
Recreation	L	*	*

Note: "H" = HIGH, "M" = MODERATE, "L" = LOW, "U" = UNCERTAIN, and "*" identifies conditions in which WET does not evaluate functions and values.

Table 7. WET Results for Arecibo Marsh Assessment Area.

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	M	L	*
Ground Water Discharge	M	M	*
Floodflow Alteration	L	H	H
Sediment Stabilization	M	H	*
Sediment/Toxicant Retention	M	H	H
Nutrient Removal/Transformation	M	H	M
Production Export	*	M	*
Wildlife Diversity/Abundance	M	*	*
Wildlife D/A Breeding	*	L	*
Wildlife D/A Migration	*	L	*
Wildlife D/A Wintering	*	M	*
Aquatic Diversity/Abundance	M	M	*
Uniqueness/Heritage	H	*	*
Recreation	L	*	*

Note: "H" - HIGH, "M" - MODERATE, "L" - LOW, "U" - UNCERTAIN, and "*" identifies conditions in which WET does not evaluate functions and values.

Table 8. WET Results for Rio Santiago Assessment Area.

	Social Significance	Effectiveness	Opportunity
Ground Water Recharge	M	L	*
Ground Water Discharge	M	M	*
Floodflow Alteration	H	M	M
Sediment Stabilization	M	L	*
Sediment/Toxicant Retention	M	L	H
Nutrient Removal/Transformation	M	L	M
Production Export	*	M	*
Wildlife Diversity/Abundance	M	*	*
Wildlife D/A Breeding	*	L	*
Wildlife D/A Migration	*	M	*
Wildlife D/A Wintering	*	M	*
Aquatic Diversity/Abundance	M	L	*
Uniqueness/Heritage	M	*	*
Recreation	L	*	*

Note: "H" - HIGH, "M" - MODERATE, "L" - LOW, "U" - UNCERTAIN, and "*" identifies conditions in which WET does not evaluate functions and values.

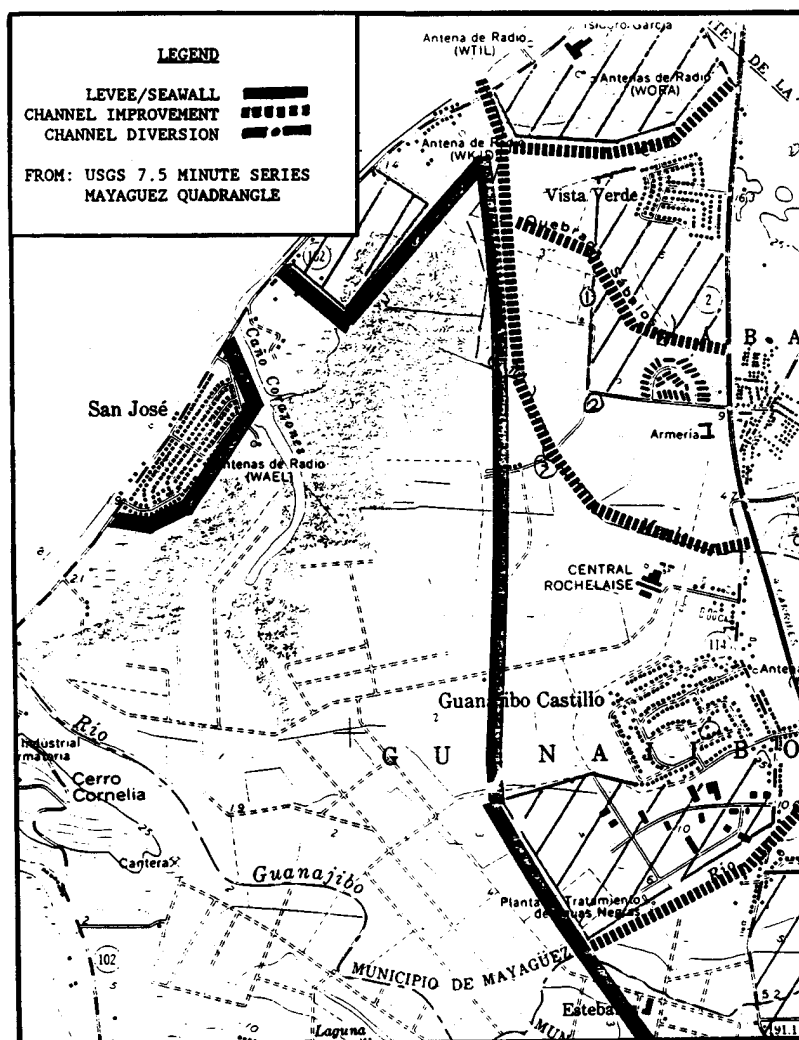


Figure 1. Proposed construction at Mayaguez, Puerto Rico

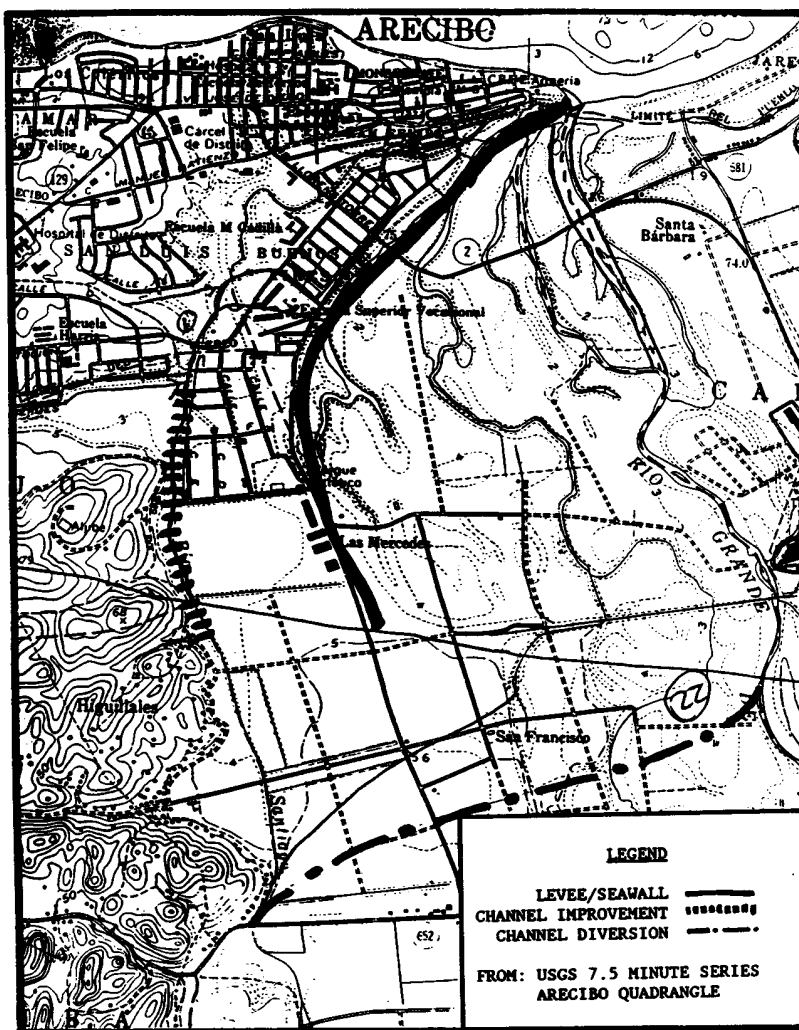


Figure 2. Proposed construction at Arecibo, Puerto Rico

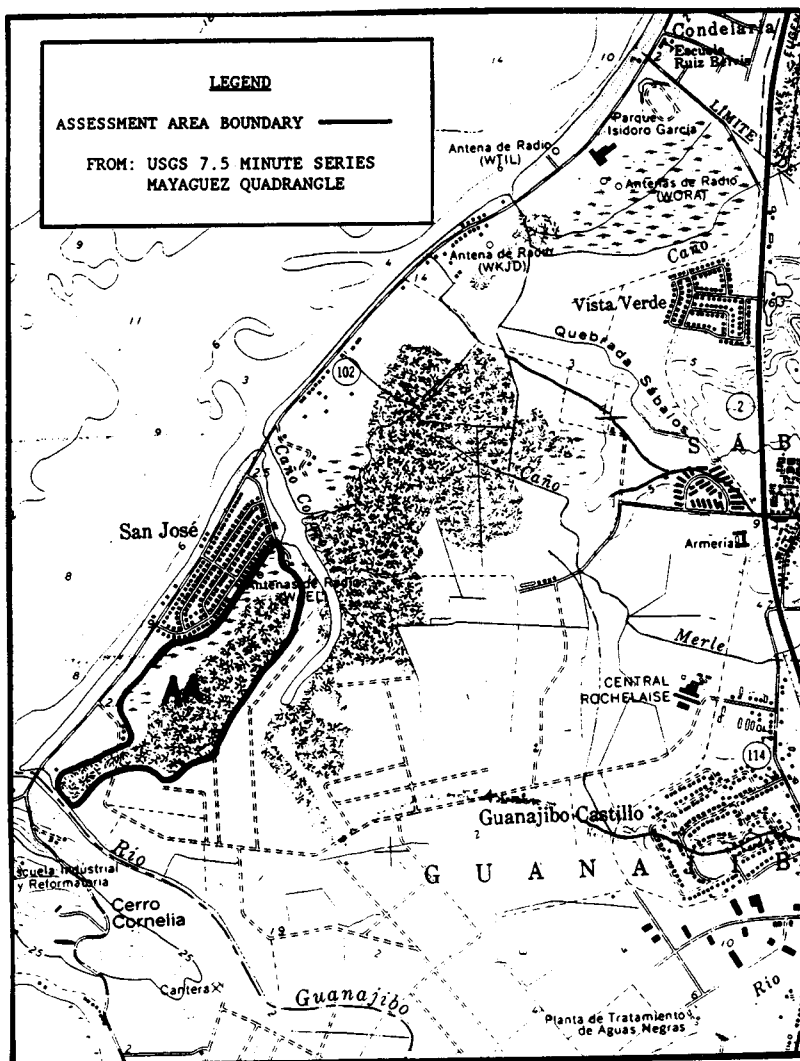


Figure 3. Guanajibo Homes assessment area

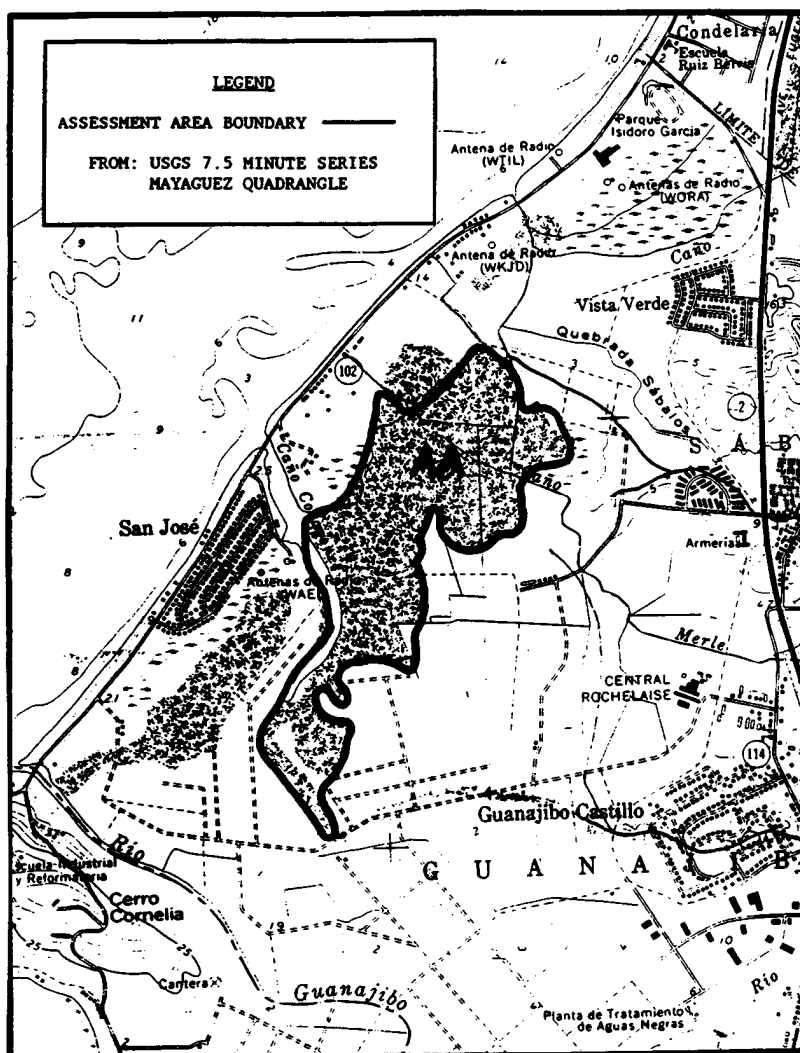


Figure 4. Cano Corazones assessment area

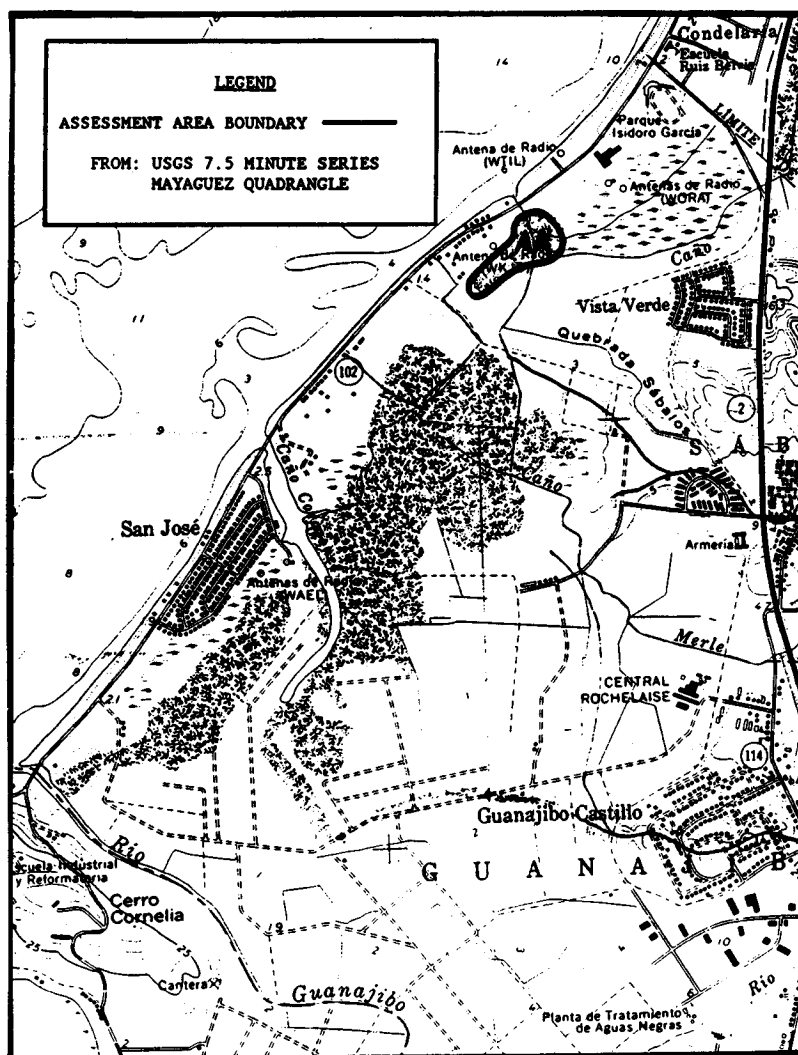


Figure 5. Cano Majagual assessment area

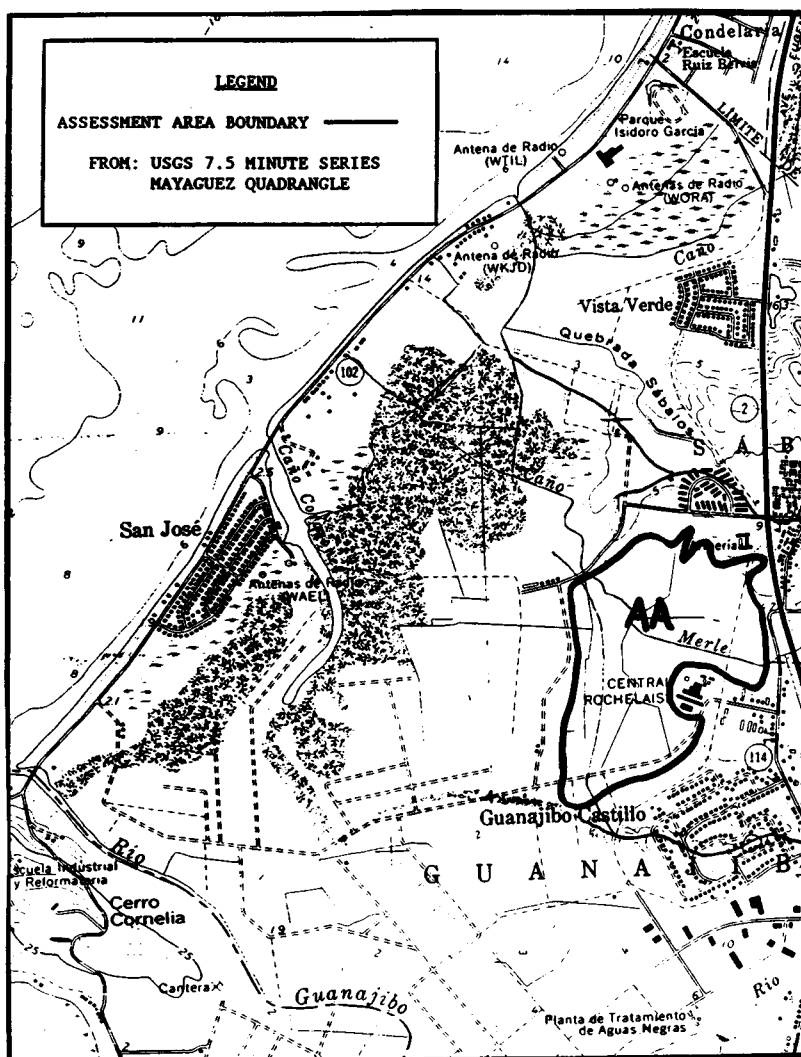


Figure 6. Merle Marsh assessment area

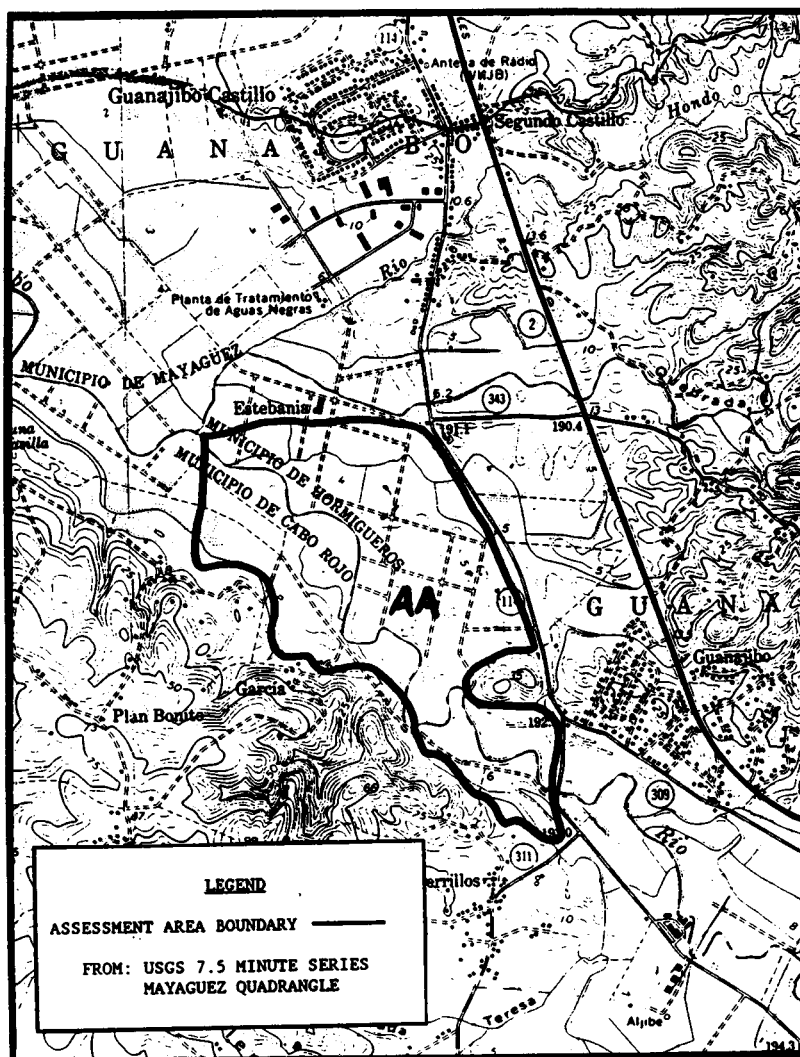


Figure 7. Guanajibo Floodplain assessment area

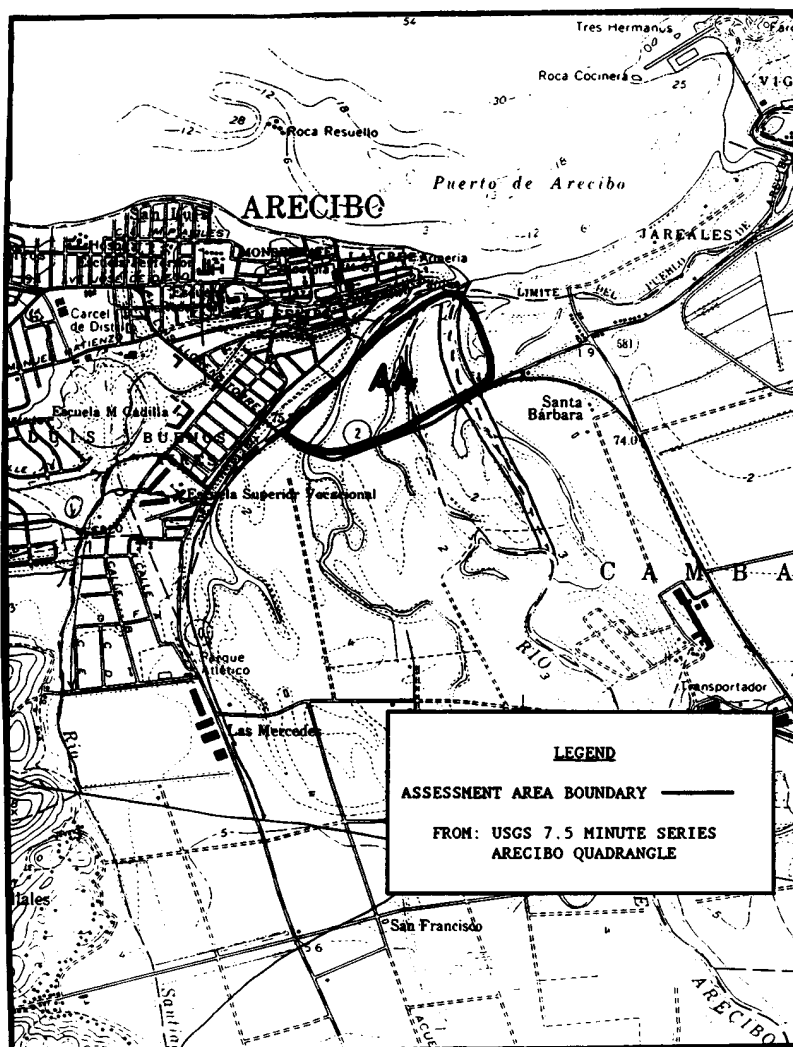


Figure 8. Mouth of Rio Arecibo assessment area

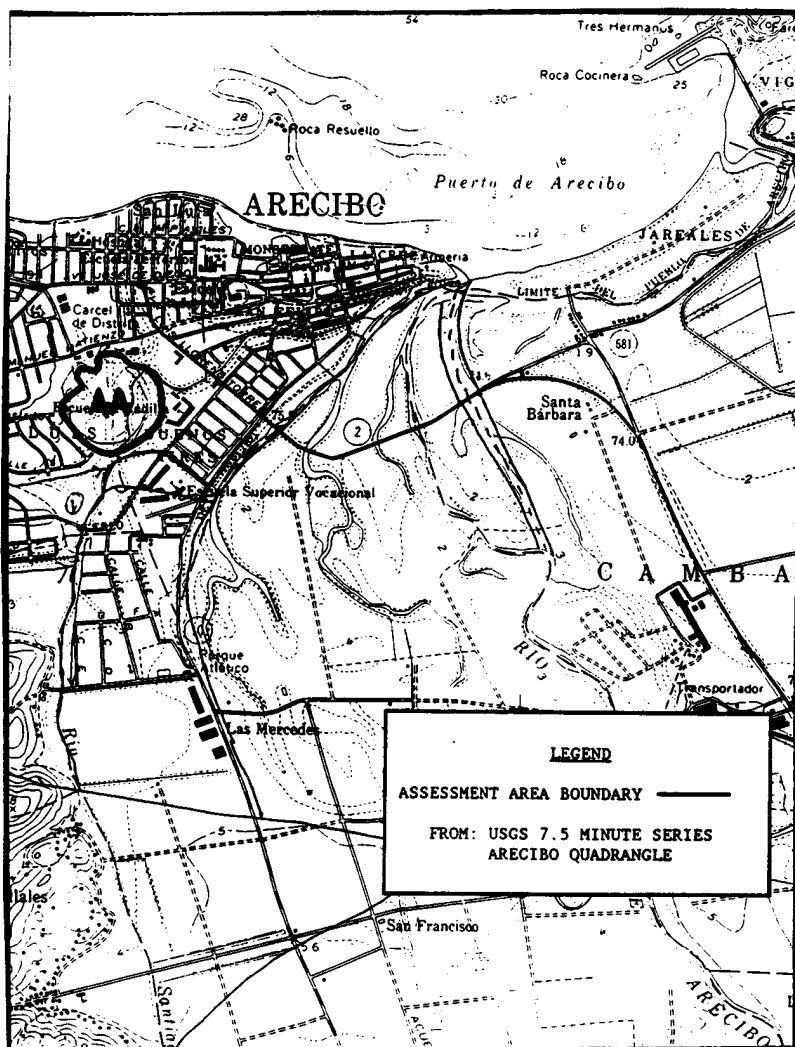


Figure 9. Arecibo Marsh assessment area

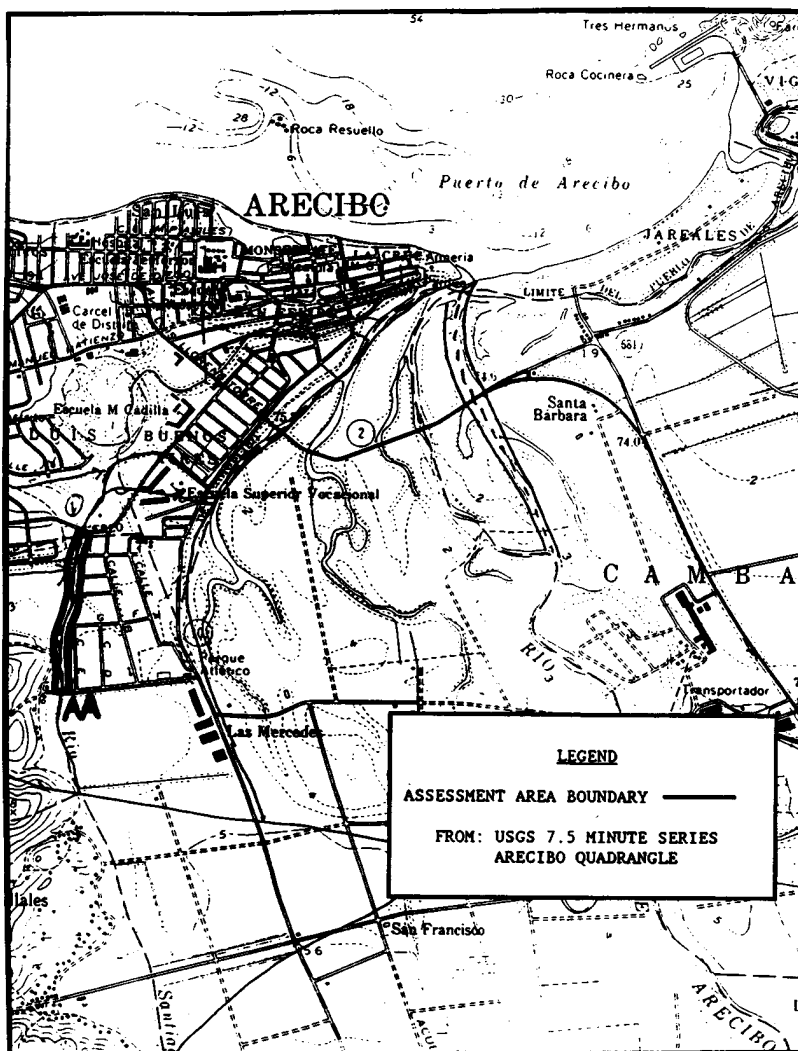


Figure 10. Rio Santiago assessment area

October 1, 1990

Planning Division
Environmental Resources Branch

Ms. Hilda Diaz-Soltero
Field Supervisor, Caribbean Office
U.S. Fish and Wildlife Service
P.O. Box 491
Boqueron, Puerto Rico 00622

Dear Ms. Diaz-Soltero:

We are currently conducting a Feasibility Study authorized by the Rivers and Harbors Act of 1962, as amended, for the Rio Guanajibo Flood Control Study, Mayaguez and San German, Puerto Rico. In accordance with Section 7 of the Endangered Species Act, we have made a no effects determination and are requesting your concurrence.

We have reviewed the literature, spoken with your staff and been on-site. According to Mr. Felix Lopez of your staff, the West Indian manatee, Trichechus manatus, feeds near the mouth of the Rio Guanajibo on aquatic plants that are washed into the ocean from the river. The brown pelican, Pelecanus occidentalis, is also known to nest near the mouth of the river.

The proposed work consists of levee construction and includes the construction of a new bridge and elevation of the existing roadway surface in the area these species are known to use (See Maps, Enclosures 1, 2 and 3). Based on this information, we have determined that the project currently being studied would not affect these species listed as endangered by the Endangered Species Act or their habitat.

If you have any questions, please contact Mr. Bill Fonferek at (904) 791-1690.

Sincerely,

A. J. Salem
Chief, Planning Division

Enclosures



United States Department of the Interior

FISH AND WILDLIFE SERVICE
CARIBBEAN FIELD OFFICE
P.O. BOX 491
BOQUERON, PUERTO RICO 00622

October 29, 1990

Mr. A.J. Salem
Chief, Planning Division
Environmental Resources Branch
Jacksonville District, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

This is in response to a letter of October 1, 1990, concerning the Feasibility Study of the Guanajibo Flood Control project, Mayagüez and San Germán, Puerto Rico. We assigned Log # 4-4-91-007 to this activity and would appreciate your referring to it in any future correspondence. Based on the information provided we consider that the project, as currently designed, is not likely to adversely affect threatened or endangered species.

This does not constitute a Biological Opinion as described under Section 7 of the Endangered Species Act, however, it does fulfill the requirements of the Act and no further action is required. If additional modifications are made in the project or if additional information indicating potential impacts to listed species become available, consultation should be reinitiated.

Sincerely,

Vance P. Vicente
Acting Field Supervisor

mtr
cc: COE, San Juan
DNR, Puerta de Tierra

MITIGATION PLAN INCREMENTAL ANALYSIS AND SELECTION

1. The selected plans (Nos. 2 and 4) described in the Draft EIS would impact 27.6 acres of mangroves located around the Rio Guanajibo and San Jose Homes Subdivisions. In accordance with the Section 404(b)(1) Guidelines actions must be taken to mitigate for these losses. Initially, the levee alignments were moved in order to avoid these losses. Secondly, the construction of floodwalls were considered to reduce the amount of fill required and the width of the levee footprint in order to reduce the amount of mangroves to be affected. The levee could additionally affect the adjacent mangroves by creating a mudwave should the mangrove root mass be removed and then construction fill placed in the new space. This mudwave would raise the adjacent mangroves to a higher elevation and reduce the amount of moisture available to the plants. This could adversely affect the growth of these mangroves, even cause plant mortality. Therefore, special conditions will be required during construction to leave this root mass in place to eliminate this impact.

2. Temporal losses were not considered significant because there would be rapid colonization of this area by mangroves as the seed source is readily available, a tropical climate with a long growing season is present, and the substrate would be adjusted to the proper elevations to allow for tidal influence of the area. During the short period of time before full canopy closure, there would be a brief period of succession from mud flats, to emergent wetland vegetation, to scrub-shrub wetlands and finally to full mangrove forest. These successional stages would provide feeding, loafing, and nesting habitat for various wading and shorebirds along the coast. In addition, inkind mitigation is generally preferred where practicable. Since no other impacts were considered relevant for mitigation other than impacts on mangroves, and the temporal losses insignificant, the use of habitat units was not considered beneficial.

3. **MITIGATION ALTERNATIVES.** Three mitigation alternatives have been identified; two inkind, one onsite and one out-of-kind offsite alternatives. The biological outputs from these three alternatives are considered equal.

a. **Plan A. (Inkind, Onsite). Selected Plan.** This alternative would involve the acquisition of 27.6 acres of land located between mangroves on the Cano Corazones and the adjacent mangrove wetland. The area would be scraped down to the elevation of the mangroves on either side of the property. Monitoring of the final elevations is critical to success. The excess material would be trucked to the borrow area and stored. No planting would be included as the site would be conducive to colonization by the adjacent vegetation. Monitoring of the mangrove colonization of the area is also necessary to insure success.

b. **Plan B. (Inkind, Onsite).** This alternative would involve the acquisition of

27.6 acres of land located between mangroves on the Cano Corazones and the adjacent mangrove wetland. The area would be scraped down to the elevation of the mangroves on either side of the property. Monitoring of the final elevations is critical to success. The excess material would be trucked to the borrow area and stored. Seed pod from the mangroves would be collected and planted approximately 1300 to the acre. Other plants such as the leather fern would also be planted to provide diversity. Monitoring of the mangrove colonization of the area is also necessary to insure success.

c. Plan C. (Offsite, Out-of-Kind). This alternative plan consists of the planting of a bottomland species, swamp bloodwood (*Pterocarpus officianalis*), within the borrow area. Initial site work would include the gathering of viable swamp bloodwood seeds and site preparation. Inspection of the subgrade and finished grade, to meet acceptable criteria for the development of the swamp bloodwood ecosystem, could be undertaken at this time. It is imperative that a suitable grade and freshwater flow is established as *Pterocarpus* seedlings cannot tolerate stagnant water. A drop-log weir structure to would allow for control of surface water runoff. Upon approval of the grade, planting of the collected seeds could begin in the nursery area. Proper construction scheduling could save the cost of transporting, growing, and transplanting swamp bloodwood saplings. The mitigation site would be established prior to planting the *Pterocarpus* seedlings because they will not survive in direct sunlight. As soon as the mitigation site is prepared, anón (*Anona glabra*), *Marcharium lunatum*, leather fern (*Acrostichum* sp.), and white mangrove (*Lagunacularia racemosa*) to establish a canopy. The seed gathering would be a labor intensive procedure requiring the qualified supervision of someone familiar with the swamp bloodwood species native to the immediate area. Planting the gathered seeds would involve coordination with knowledgeable individuals familiar with the regions rainy season and the rivers hydroperiod to assure proper seed germination and survival. Follow-up monitoring of the project would determine survival rate and needed plant replacement to fulfill the proper density of young saplings to establish a viable swamp bloodwood ecosystem. A contracted maintenance period would help to insure the development of the saplings into a full fledged forest. Supervision by a *Pterocarpus* expert, Dr. Migdalia Alvarez, Puerto Rico University Biology Department, Ponce, would ensure success. The prospect of graduate student fieldwork assistance for the development and recording of pertinent data could help ensure the projects success. The Rio Guanajibo *Pterocarpus* mitigation would be a proving ground for a new and viable type of wetlands reconstruction.

4. OUTPUT ASSESSMENT AND COST ESTIMATE

(1) Management Measures	(2) Management Measure Increments	(3) Outputs	(4) Costs
No Action	None	0	\$0
Plan A	None	27.6 Acres	\$311,100

(1) Management Measures	(2) Management Measure Increments	(3) Outputs	(4) Costs
Plan B	None	27.6 Acres	\$365,200
Plan C	None	27.6 Acres	\$480,000

5. ALTERNATIVES THAT ARE NOT LEAST COST COMBINATIONS (Shaded areas).

(1) Management Measures	(2) Outputs	(3) Costs
No Action	0	\$0
Plan A	27.6 Acres	\$311,100
Plan B	27.6 Acres	\$365,200
Plan C	27.6 Acres	\$480,000

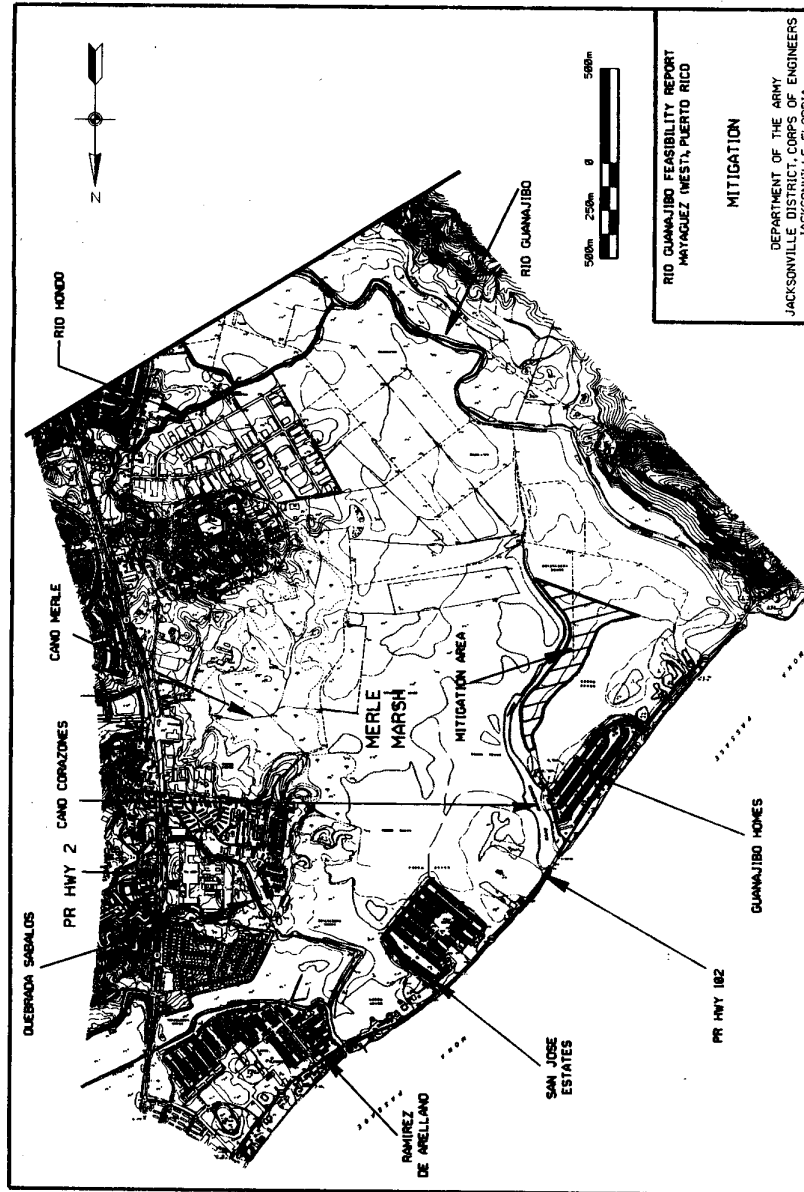
6. OUTPUTS AND COSTS OF LEAST COST COMBINATIONS FOR EACH LEVEL OF OUTPUT.

(1) Management Measures	(2) Outputs	(3) Costs
No Action	0	\$0
Plan A	27.6 Acres	\$311,100

Since only one alternative exists other than No Action, no further derivation of plans is necessary. Plan A is the least cost alternative having the desired output. However, the US Fish and Wildlife Service has expressed a desire to have included in the mitigation plan the gathering and planting of mangrove seeds. Since this is a relatively minor cost, we have selected this additional feature to be included in the mitigation plan.

7. HABITAT ENHANCEMENT OPPORTUNITIES. Even though the use of the borrow area as a mitigation site was not selected, it does present an opportunity to

create wetland habitat within the Mayaguez area. When the site is no longer needed for borrow material, it could be designed and contoured to provide freshwater wetlands such as Merle Marsh or the creation of a *Pterocarpus* sp. forest which would provide an excellent scientific study opportunity for the Department of Natural Resources or a local university. This would require acquisition of the borrow area in fee. This could be done during PED Phase. In addition, the culvert which connects Cano Corazones and the leveed area around Guanajibo Homes Subdivision which allows drainage of residual flooding from behind the levee would be evaluated as a two-way structure to allow estuarine tidal flows/flushing in order maintain the 6.0 acre mangrove wetland cut off by the levee.



RIO GUANAJIBO FEASIBILITY REPORT
MAYAGUEZ WEST, PUERTO RICO

MITIGATION

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA



United States Department of the Interior

FISH AND WILDLIFE SERVICE
Caribbean Field Office
P.O. Box 481
Boqueron, Puerto Rico 00622

September 19, 1994

Mr. A. J. Salem
Chief, Planning Division
US Army Corps of Engineers
PO Box 4970
Jacksonville, Florida 32232

Re: Guanajibo Flood Control

Dear Mr. Salem:

This is in regards to the recent modifications that have occurred with the Guanajibo Flood Control Project. These modifications include the elimination of the Caño Majagual portion of the project and additional flood protection for an existing radio station. This additional protection would entail the isolation of 6 acres of mangroves between the levee and an existing subdivision.

The isolated mangroves would either convert slowly to freshwater wetlands as salinity decreases, or more likely will be subject to development since the area will be protected from flooding.

We recommend that the Corps seek to minimize to the maximum extent possible the isolation of these mangroves. Alternatives such as extending the flood wall around the radio station, or realignment of the levee closer to the subdivision should be discussed in the Final EIS.

Since the Majagual portion has been eliminated we agree with the Corp's determination of a 1:1 mitigation ratio with planting. We look forward to continued coordination during the design phase of the mitigation plan. If you have any questions please call Felix Lopez of my staff.

Sincerely,

James P. Oland
James P. Oland
Field Supervisor

fh1
cc:
DWR, San Juan
COE, San Juan
ARD, FWS, Atlanta

OPTIONAL FORM NO. 10 (7-89)	
FAX TRANSMITTAL	
To: Roberto Cotes	From: Felix Lopez
Subject: Planning	File #
Date: 9/19/94	Page #
NEN 7540-27 317-7580 3089-101 GENERAL SERVICES ADMINISTRATION	

September 7, 1994

Planning Division
Environmental Branch

Mr. James P. Oland
Field Supervisor
Caribbean Field Office
U.S. Fish and Wildlife Service
P.O. Box 491
Boqueron, Puerto Rico 00622-0491

Dear Mr. Oland:

This is in reference to the Rio Guanajibo Flood Control Feasibility Study. My Environmental Branch staff has discussed changes which recently were made to this project with Mr. Felix Lopez of your staff.

Since the coordination of the Draft Environmental Impact Statement for the project, several features of that project have been modified. The channel modification of and bridge replacement over the Cano Majagual have been eliminated. This action would eliminate all impacts to the freshwater (cattail) wetlands adjacent to the channel and approximately 0.91 acre of mangroves and/or *Pterocarpus officianalis* near the mouth of the Cano Majagual. In addition, it was necessary to protect the radio station behind the Guanajibo Homes Subdivision adjacent to the Cano Corazones. The new levee alignment (previously faxed to your office) would take the same amount of mangroves as the original alignment but would isolate a 6-acre tract between the levee and the subdivision.

The mangroves would remain viable in the isolated area for a long period of time until the salinity decreases, then, it would be likely that a freshwater environment would colonize the area. A large culvert is proposed for inclusion in the levee design to drain residual flooding from the subdivision. During the Detailed Engineering Phase of this project, the design of this culvert will be reviewed to determine if it could accommodate tidal flushing which would allow the mangroves to remain intact.

The total amount of mangroves affected by the levee would now total 27.6 acres as compared to the 22.5 acres originally proposed. This new figure includes the 6-acre tract between the levee and the Guanajibo Homes subdivision, minus the 0.91 acre of mangroves that will not be affected as a result of dropping the project features at Cano Majagual. It is still proposed that the

mitigation for mangrove losses be at a 1 to 1 ratio. The mitigation plan also calls for monitoring of the mitigation area. We would like to assure you that the mitigation plan will be fully carried out as proposed and if the design does not yield the desired results it will be corrected. Technically, the plan to reduce the elevation of the mitigation area to grow mangroves is proven. However, in order to provide more assurance, we would include mangrove seed gathering and planting as an extra feature since the costs are minimal.

Sincerely,

A. J. Salem
Chief, Planning Division

STRAIN ———
 Ponferek/CESAJ-PD-ES KH
 Kurzbach/CESAJ-PD-ES
 Smith/CESAJ-PD-E
 Davis/CESAJ-PD-A
 Salem/CESAJ-PD



United States Department of the Interior

FISH AND WILDLIFE SERVICE
Caribbean Field Office
P.O. Box 491
Boqueron, Puerto Rico 00612



August 18, 1994

Mr. A. J. Salem
Chief, Planning Division
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Re: Rio Guanajibo Flood Control

Dear Mr. Salem:

We have reviewed the Draft Feasibility Report and DEIS for the proposed Guanajibo Flood Control Project. The Service has been working closely with the Corps in the planning phase of the project. After a careful review we have the following comments:

Mitigation Plan:

The Service's comments on mitigation have changed as the project design has evolved throughout the years. The Service's most recent comments of October 1993, recommended a 3:1 mitigation ratio based on the loss of Pterocarpus wetlands from the proposed Caño Majagual channel improvements. The Corps' Addendum to the Draft Feasibility Report states that these channel improvements are being re-evaluated and will be dropped if not economically justified. The Service's final comments and recommendations on the proposed mitigation strategy will depend on the Corps' decision.

The proposed mitigation plan (Exhibit V, DEIS) calls for a 1:1 ratio consisting of the acquisition of 22.5 acres of land to be graded and left to natural colonization. Although a 1:1 ratio could eventually compensate for the loss of wetlands impacted, very few wetland creation plans are 100% successful. The wetlands being impacted are mature mangrove forests which have not been impacted by storms for over 30 years. It would take 30-50 years for the trees in the mitigation area to reach the same height and diameter. A ratio of 1.5:1 would compensate for the loss of habitat and services provided by that habitat and reflect the delay in reaching the desired wetland system. Leaving the area to natural revegetation could result in the area being invaded by fast growing weedy species that would slow colonization by mangroves and other preferred vegetation. This


would lower the habitat value of the area over a longer period of time. Rather than leaving the area to natural processes, we believe that planting of black and white mangrove seedlings and broadcasting of black and white mangrove seeds would better insure success. If the Corps wishes to leave the area to natural revegetation then a greater than 1.5:1 mitigation ratio should be considered since it would take much longer for the area to be colonized by wetland vegetation.

We agree with the Habitat Enhancement Opportunities presented in Part 7 of the Mitigation Plan. However due to the experimental nature of planting Pterocarpus and the creation of freshwater forested wetlands, any effort in this area should be strictly in addition to the regular mitigation.

Once a mitigation plan is decided upon, the grading and actual contours should be calculated during the Planning and Specification Phase. A final mitigation plan complete with as built engineering drawings should be reviewed by the Service prior to final approval.

If you have any questions please contact Felix Lopez at 809-851-7297.

Sincerely,


Susan Silander
Acting Field Supervisor



United States Department of the Interior

FISH AND WILDLIFE SERVICE
Caribbean Field Office
P.O. Box 491
Boqueron, Puerto Rico 00622



October 13, 1993

Mr. A. J. Salem
Chief, Planning Division
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Re: Rio Guanajibo Flood Control

Dear Mr. Salem:

Enclosed are two copies of our draft Coordination Act report for the proposed Rio Guanajibo Flood Control measures. This report is issued in accordance with Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). This report is presented as partial fulfillment of the FWCA and does not constitute a final Section 2(b) report. A final report will be issued once a final mitigation plan is developed.

If you have any questions please contact Felix Lopez of my staff.

Sincerely,

James P. Oland
Field Supervisor

FWCA Report for Rio Guanajibo Flood Control Project

Prepared by:
Felix Lopez
US Fish and Wildlife Service
Caribbean Field Office

Executive Summary

The US Army Corps of Engineers is proposing flood control works in the Rio Guanajibo, Mayaguez, Puerto Rico. There are currently two proposed alternatives. Alternative #1 envisions a 6 kilometer levee and two ring levees around existing San Jose and Guanajibo Homes housing developments. The ring levees will impact the basin mangrove forest that grows adjacent to the developments. This alternative would also impact Merle Marsh, cutting it off from the existing Guanajibo wetlands. This marsh is important in providing hydrology to the mangroves and marshes to the south. Alternative M-8 calls for the levee to end east of Merle Marsh at Guanajibo Castillo. This would avoid impacts to the marsh. Ring levees around the existing housing developments will continue. The plan also calls for channel improvements along Caño Majagual. These channel improvements would impact a freshwater forested Pterocarpus swamp. Most of Puerto Rico's Pterocarpus forests were drained for agriculture in the last century. Remnant Pterocarpus forests are considered rare habitat types and critical in maintaining the biodiversity of Puerto Rico's wetland habitats. The Service is recommending that channel improvements along Caño Majagual end above the Pterocarpus forest thus avoiding impacts to the system.

The Corps is proposing for mitigation the creation and enhancement of a mangrove area adjacent to Caño Corazones. The area exhibits hydric characteristics and is currently being impacted by cattle grazing and unauthorized fills. A final mitigation plan with mitigation ratios, detailed planting schemes, and elevations has yet to be developed.

Project Description:

The Rio Guanajibo drains approximately 330 square kilometers in the west central portion of Puerto Rico. The steep descent and short floodplain causes rapid flooding during storms. Most of the floodplain consists of sugarcane fields and cattle pasture. Development along the river is restricted to the town of San German and the coastal floodplain in Mayaguez. There are currently two alternatives proposed for flood protection in Mayaguez. Alternative #1 was the selected plan, which calls for a 6 kilometer long levee to protect most of the existing developments and a ring levee around Guanajibo Homes. Another plan M-8 is now being considered. This plan calls for a series of ring levees instead of a continuous levee.

Resources:*Soils:*

Soils in the lower Guanajibo floodplain consist mostly of Tidal swamp (Td) a hydric soil, Bajura clay (Ba) a hydric soil, Coloso silty clay (Cn) a soil with hydric characteristics and inclusions of Bajura, Alluvial Land (An) a soil recently classified as hydric by SCS and Leveled sandy land (Lm) a poorly classified soil that can have hydric characteristics or inclusions. Most of the land in the project area is considered prime agricultural land and although many fields near the river mouth have been abandoned, sugarcane is still actively grown in the upper portions. Beef cattle are being raised in the central portion of the project area near Merle Marsh.

Wetlands:

Wetlands in the project consist of basin mangroves dominated by black mangroves (*Avicennia germinans*), white mangroves (*Laguncularia racemosa*), and leather fern (*Acrostichum* sp.). This mangrove swamp is the dominant wetland type in the area and extends from the river mouth to San Jose development. These mangroves support a large number of migratory and resident waterfowl, red-tailed hawks, osprey, herons, egrets, etc. (see PAL for a complete list of birds). Past surveys conducted by the Service indicate that these mangroves are used for nesting by yellow-crowned night herons, and cattle egrets, and serve as a roost for little blue herons (Pace, 1986).

Riverine mangroves are restricted mainly to the Caño Corazones area. They consist of red mangroves (*Rhizophora mangle*) and black mangroves. The Caño Corazones area appears to be an old river mouth. It is now a tidal creek and serves as a relief channel during major flood events. The Caño's mouth is closed during months of low rainfall and opens during heavy rains events. It is an important estuary system that supports artisanal and recreational fishermen.

Freshwater wetlands in the site are divided into forested and herbaceous wetlands. Merle Marsh is the largest herbaceous wetland on the site. The marsh is located between the National Guard Armory to the west and Guanajibo Castillo to the east. The marsh grades south into the basin mangroves behind Caño Corazones. Merle Marsh serves to filter urban

runoff before it reaches the mangroves and also provides sheet flow into the mangroves thus assuring proper hydrology. The marsh has been impacted by ditching, and fills around the edges. The central portion of the marsh remains intact. Marsh vegetation include giant sedge (Cyperus giganteus), alligator flag (Thalia geniculata), jacobs tears (Coix lacrym-jobi), and cattails (Typha domingensis).

Two forested freshwater wetlands are found in the site. The larger of the two Pterocarpus officinalis forests is found at the mouth of the Rio Guanajibo. It is composed mainly of Pterocarpus, leather fern, and native royal palm (Rovstonea borinquena), a smaller Pterocarpus forest is found near the mouth of Caño Majagual. This forest is a bit more complex with escambrón (Machaerium lunatum), leather fern, and royal palm. Freshwater forested wetlands can be considered an "endangered" habitat type in Puerto Rico. This wetland type has all but disappeared from the island due to agricultural development in past centuries. These remnant forests represent the only forested swamps that are left in the Rio Guanajibo flood plain. Their importance to wildlife and the natural heritage of Puerto Rico is very high.

Wildlife:

The Service's 1986 Planning Aid Report describes in detail the wildlife and fisheries resources of the area. Caño Corazones and the Rio Guanajibo river mouth are both important estuary areas and are used by local fishermen. Sport fisherman also frequent these areas to fish for tarpon (Megalops atlantica), snook (Centropomus sp.) and other sport

fish found in the estuary.

The mangroves and marshes of the Rio Guanajibo provide habitat for numerous water birds. Moorhens (Gallinula chloropus) nest in the mangroves, Caribbean coots (Fulica caribea), little blue heron (Florida caerulea), snowy egrets (Egretta thula), great blue herons (Ardea herodias), green backed heron (Butorides striatus), tri-colored heron (Hydranassa tricolor), and great egret (Casmerodius albus) all use the wetland for feeding and roosting. Both yellow-crowned night herons (Nyctanassa violacea) and black-crowned night herons (Nycticorax nycticorax) nest in the area of Caño Corazones. The yellow breasted crane (Porzana flaviventer) has also been reported for the area. These wetlands are the largest mangrove/marsh system in the Mayaguez area and provide essential habitat to the area's wildlife. See Pace, 1986, PAL for more detail and species lists.

Project Impact:

1) Alternative #1. This alternative would create a levee some 6 kilometers in length that would extend from the Route #100 bridge to Caño Majagual. Recent surveys revealed that a new housing development has been constructed on the hill that the levee was planned to anchor into near Route 100 (Fig. #1). This hill has been eliminated by the housing development. A borrow canal is to run the length of the levee and discharge into Caño Majagual. The levee would wrap around the San Jose community and end at Route #102. The levee would pass through the southern boundaries of Merle Marsh, isolating it from the rest of the Guanajibo wetlands. It would also block sheet flow hydrology from reaching the

mangrove wetlands. This laminar flow is vital to maintaining proper wetland hydrology. Plans to install some form of culvert along the levee route, would aid in maintaining hydrology but would change flow patterns from laminar to point source. The proposed borrow channel would impact the smaller Pterocarpus wetlands near the mouth of Caño Majagual, disrupting hydrology and possibly eliminating it totally.

2) Alternative M-8 would be less impacting, since the levee route will not cross Merle Marsh. The levee will veer north, immediately after Guanajibo Castillo. It will follow a ridge and only impact the eastern most edges of Merle Marsh. This would assure proper hydrology to the Guanajibo mangrove forest and provide needed flood protection. Another levee will head south from the Sabalos area to the San Jose development. The levee will be constructed as close as possible to the existing San Jose development. This levee would impact freshwater marsh and mangrove wetlands associated with the San Jose Development. A ring levee would surround Guanajibo Homes. This levee would also impact well developed basin mangroves along most of its course.

Channel improvements are also being planned for Caño Majagual. Since the Caño is bordered by the Ramirez de Arellano Development along most of its western bank, access to the Caño would have to be from the east. Herbaceous wetlands border most of the eastern banks of the Caño. South of the confluence of Quebrada Sabalos and Caño Majagual there exists a well developed moist forest and the remnant Pterocarpus swamp (Fig. #2) any channel improvements in this area would adversely impact these systems.

Channel improvements continue past the Route 102 bridge to the sea.

Recommendations:

The least impacting of the planned alternatives is Alternative M-8. This alternative would avoid all impacts on Merle Marsh and not interfere with the hydrology of the mangrove wetlands. The plan will still impact the basin mangroves that border San Jose and Guanajibo Homes. The extent of impacts depends on the construction methods and levee design. Mitigation for mangrove losses should be at a minimum 3:1 ratio. Mangrove forests under ideal conditions will take at least 10-15 years to reach maturity and complexity. Several mitigation sites and alternatives have been discussed in past reports. All have been discarded either because of their complexity or highly experimental nature. Mangrove creation has been chosen to be the most effective form of mitigation for this project. The proposed mitigation site is what seems to be an old river berm located just east of Caño Corazones (Fig. #3). It is a fairly large wedge of slightly higher ground bordered on both sides by mangrove forest. The grading of this area to a few inches below the existing mangroves would assure proper hydrology. A mixture of black and white mangrove seedlings should be planted throughout the area along with leather fern, and other wetland plants. In addition to the seedling plantings, mangrove seeds can be dispersed throughout the area.

Channel improvements of Caño Majagual should stop north of Quebrada Sabalos. Bank protection along the western banks adjacent to the Ramirez de Arellano development would

not impact the swamp. Improvements to the Route 102 bridge and improvements south of the bridge can continue. This would avoid impacts to the important wetlands in the area.

The Puerto Rico Highway Authority is planning a Mayaguez bypass just east of the National Guard Armory, connecting into Route 102 between Ramirez de Arellano and San Jose Development. Coordination will be needed to assure that the projects do not conflict.

A final mitigation plan should be submitted by the Corps once the project enters the design phase. This mitigation plan should be reviewed by all interested resource agencies. A final Coordination Act Report will be issued once a final design plan and mitigation plan are established by the Corps.

References

- Cardona J. and Rivera M., 1988. Critical Coastal Wildlife Areas of Puerto Rico, PR Department of Natural Resources, pp 27
- Gierbolini R., 1975. Soil Survey of Mayaguez Area of Western Puerto Rico, US Department of Agriculture, Soil Conservation Service
- Kaplan E. 1988. Peterson Field Guide, Southeastern and Caribbean Seashores, Houghton Mifflin Co.
- Liogier A., and Martorell L., 1982. Flora of Puerto Rico and Adjacent Islands: A Systematic Synopsis, Editorial Universitaria, UPR
- Martorell L. et al, 1981. Catalogo de los Nobres Vulgares y Cientificos de las Plantas de Puerto Rico, Agricultural Experimental Station Bulletin #263, UPR, Mayaguez
- National Oceanographic Administration, 1978. Puerto Rico Coastal Management Program and Final Environmental Impact Statement
- Pace R., 1986. Planning Aid Report, Rio Guanajibo Flood Control Project. US Fish and Wildlife Service
- Raffaele H., 1989. A Guide to the Birds of Puerto Rico and the Virgin Islands, Princeton University Press
- Reed P., 1988. National List Of Plant Species That Occur In Wetlands: Caribbean (Region C), US Fish and Wildlife Service Biological Report 88(26.12)

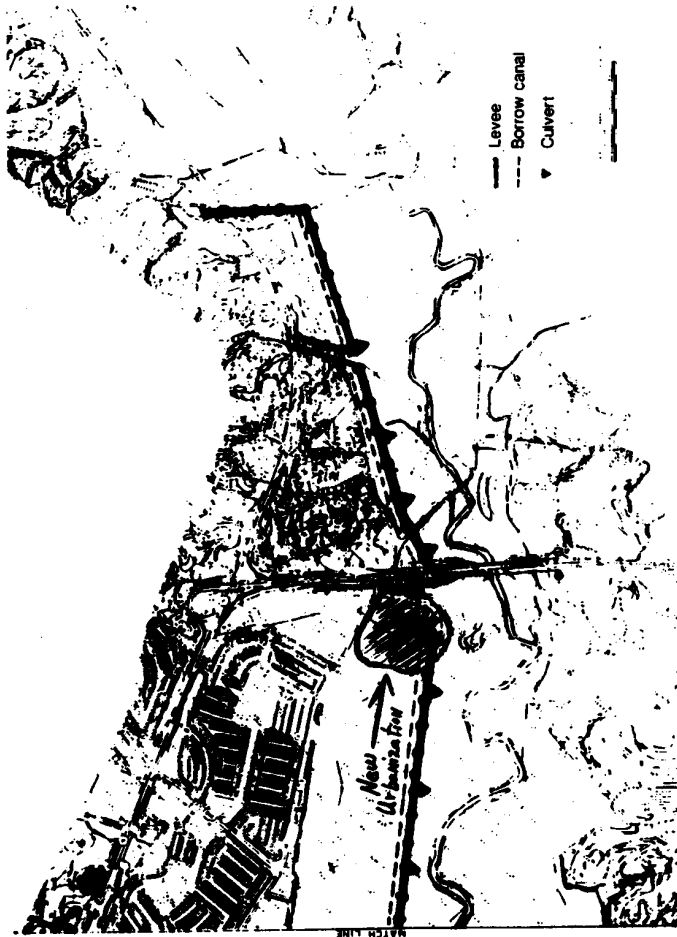
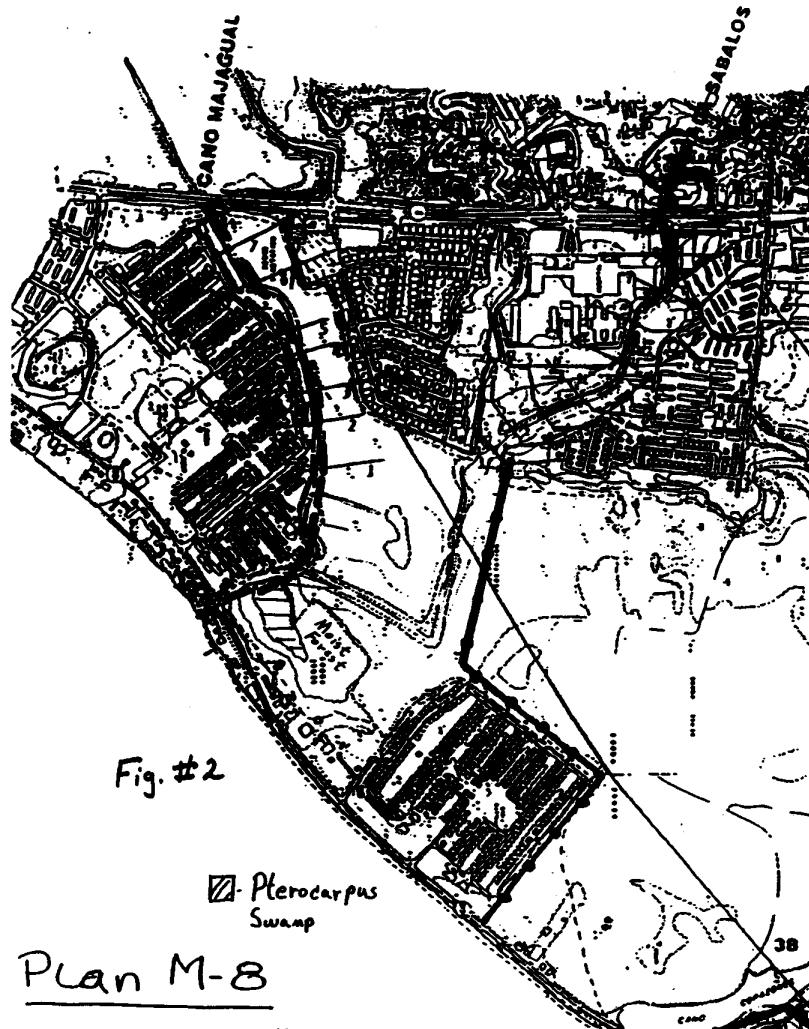
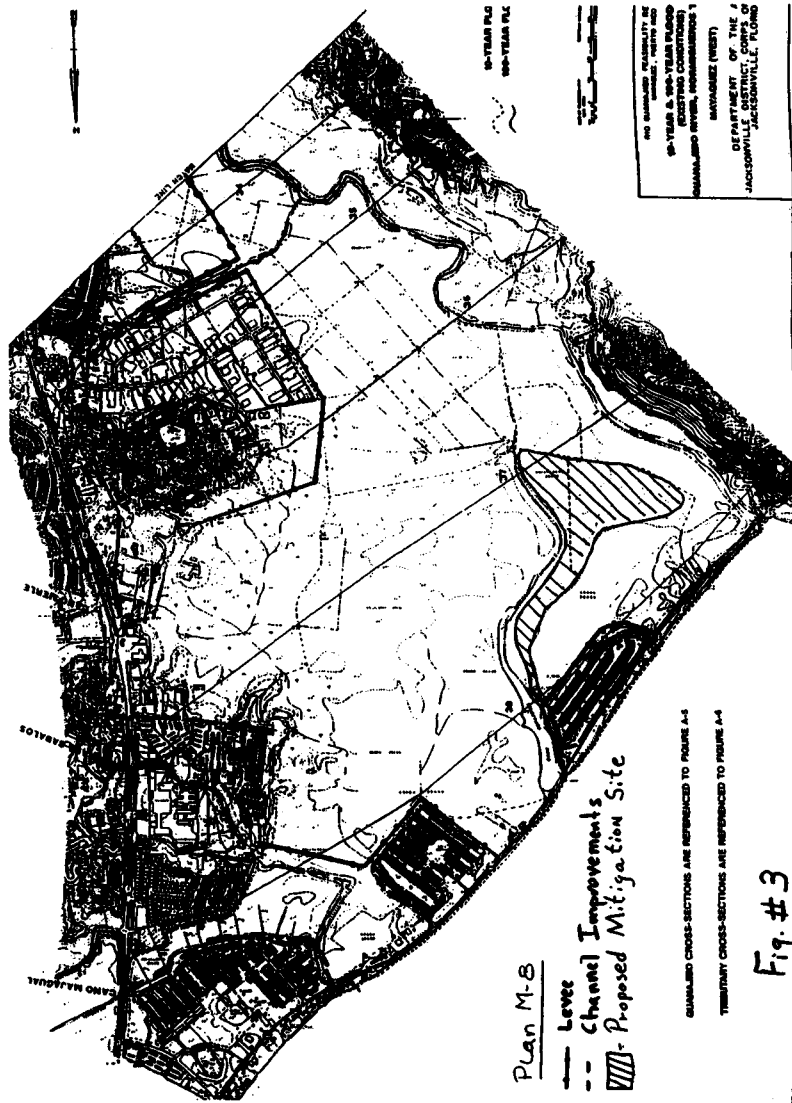


Fig. #1

US Army Corps of Engineers
Jacksonville District
SELECTED PLAN (MAYAGUEZ EAST)
Rio Guansajibo Flood Protection Study







United States Department of the Interior

FISH AND WILDLIFE SERVICE
CARIBBEAN FIELD OFFICE
P.O. BOX 491
BOQUERON, PUERTO RICO 00622

January 15, 1991

Mr. A. J. Salem
Chief, Planning Division
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Re: Guanajibo Flood
Control

Dear Mr. Salem

The interested agencies of the Department of the Interior have reviewed the above referenced flood control project. Our comments are issued in accordance with the Fish and Wildlife Coordination Act (48 Stat.401, as amended; 16 U.S.C. 661 et seq.).

The Corps proposes to construct a levee and flood wall system in the Municipalities of San German and Mayaguez to protect developed areas from the Rio Guanajibo floods. Our office has been working closely with the Corps in all phases of this project.

The lower Guanajibo falls within the subtropical moist forest ecological life zone (Ewel & Whitmore, 1973). Vast areas of lowland forest were converted for sugarcane agriculture in the last century. With the recent decline in sugarcane many of these fields have become abandoned and are slowly reverting back to wetlands. Like most of Puerto Rico's rivers, the steep descent of the Guanajibo and its tributaries causes rapid flooding in the coastal plain.

Extensive mangrove and Pterocarpus wetlands are found in the lower Guanajibo near the mouth. Mangroves cover some 282 acres forming a well developed riverine type forest around Caño Corazones. The riverine forest extends back into a basin forest dominated by black and white mangroves. The mangrove lined watercourses of Caño Corazones are a very productive estuary and provide nursery habitat for marine species, as well as roosting habitat for numerous waterfowl.

The most outstanding feature of the Guanajibo wetlands is the swamp Pterocarpus forest found near the mouth. The area covers some 7 acres. This type of forested wetlands is considered an endangered habitat type in Puerto Rico.

The area around San German has been severely altered by human activities. The surrounding river banks are use as cattle pasture and have low fish and wildlife value. The river flows through the town and bank vegetation is severely restricted.

The Corps' proposed levee will traverse several fresh water wetland systems. The most important of these is Merle marsh. The upper portions of Merle marsh will be isolated by the levee. This marsh provides freshwater runoff to the lower wetlands in the area. Adequate measures should be taken to insure that these wetlands do not become hydrologically isolated. Wetlands near the Caño Majagual wetlands could be impacted by the Corps' proposed borrow channel. We recommend that the alignment of the borrow channel follow that of the existing Quebrada Sabalos. Channel improvements in Caño Majagual should be restricted to the northern banks as much as possible.

The proposed borrow areas for the lower Guanajibo will mostly impact existing sugarcane fields south of the Mayaguez. The eastern borrow area will impact some riverine wetlands and a small oxbow pond. Borrow areas in San German will impact uplands dedicated primarily to cattle pasture.

The eastern borrow area below the Road 100 bridge could be used for wetland enhancement measures to mitigate for impacts to existing wetlands. The Corps' proposed mitigation plan consists of creating a strip of wetlands along the Guanajibo starting at the confluence of the Rio Hondo. We recommend that the strip be extended to join with the Caño Corazones wetlands. This would form a contiguous wetland area adjacent to the Guanajibo. This would also increase flow into Caño Corazones.

Another mitigation option is the expansion of existing wetlands at the mouth of the Guanajibo. The existing Pterocarpus and mangrove forests can be extended as outlined in our Planning Aid report.

We recommend that a mixture of mangrove and freshwater vegetation be planted in all mitigation sites. Pterocarpus seedlings cannot stand full sunlight, some form of shade vegetation must be established prior to the planting of Pterocarpus.

We suggest that the initial planting consist of the following freshwater species, escambrón (Machaerium lunatum), mangrove annona (Annona glabra), white mangrove (Laguncularia racemosa), native royal palm (Roystonea borinquena) and leather fern (Acrostichum spp).

Other mitigative measures that can be taken are the elimination or blockage of drainage canals that crisscross the lower Guanajibo floodplain, especially those that drain the existing forested wetlands. If these drainages are blocked, wetlands will expand naturally as the hydrology slowly changes to a wetter regime.

Currently the Corps' mitigation plan is still in a conceptual phase, we will reserve final comment upon the receipt of a more concrete mitigation plan.

Thank you for the opportunity to comment on this action, if you have any questions please contact Felix Lopez of my staff.

Sincerely,



Vance P. Vicente
Acting Field Supervisor

fhl
cc:
COE, San Juan



United States Department of the Interior

FISH AND WILDLIFE SERVICE
CARIBBEAN FIELD OFFICE
P.O. BOX 491
BOQUERON, PUERTO RICO 00622

January 15, 1990

Mr. A.J. Salem
Chief, Planning Division
US Army Corps of Engineers
PO Box 4970
Jacksonville, Florida 30032

Re: Guanajibo Flood
Control Project.

Dear Mr. Salem:

Enclosed is a Planning Aid Report for the proposed borrow sites and Caño Majagual. If you have any questions please do not hesitate to contact Felix Lopez of my staff.

Thank you for the opportunity to comment on this action.

Sincerely,

Vance P. Vicente
Acting Field Supervisor

fhl
cc:
COE, San Juan

Planning Aid Report
Guanajibo Flood Control Project

Written by:
Felix Lopez
Fish and Wildlife Service
Caribbean Field Office

Project Description:

The Guanajibo River drains approximately 329 square kilometers in the west coast of Puerto Rico. The mountainous topography of the Cordillera Central and prevailing easterly winds results in abundant rainfall. The steep descent of the tributaries causes rapid flooding in the coastal plain.

The Corps is proposing the construction of levees, and flood walls between existing developments in San German and Mayaguez and the Guanajibo floodplain. Drainage for the levee in the lower Guanajibo will consist of a borrow channel on the north side of the levee running parallel and connecting with Caño Majagual. Channel improvements along Caño Majagual will consist of a gabion channel. Borrow areas have been identified for levee construction in Mayaguez and San German.

Soils:

Soils in the project area range from tidal swamp in the lower Guanajibo floodplain to Reilly gravelly soils in San German. Wetland soils in the lower Guanajibo at Mayaguez consist of Td (Tidal swamp), Ba (Bajura series), Cn (Coloso series), Lm (Leveled sandy land), An (Alluvial land). Tidal swamp soils contain basin mangrove wetlands, and swamp Pterocarpus.

The other soil series support various degrees of herbaceous wetlands, and low land secondary forest.

Caño Majagual Wetlands:

Caño Majagual flows through the town of Mayaguez. It is channelized through most of its course. Past highway 2 the creek is bordered on the north by the Ramirez de Arellano housing development, to the south there is a mixture of wetlands and uplands (Figure 1). The creek provides overflow to Majagual Marsh, a herbaceous freshwater marsh, and a basin mangrove forest near the mouth. Vegetation at the road 102 bridge consists of white mangroves (Laguncularia racemosa), leather fern (Acrostichum sp.), royal palm (Roystonea borinquena). Vegetation immediately north of road 102 consists of West Indian almond and coco palms. Wetlands extend southwest of Caño Majagual. These wetlands consist of basin type mangroves grading into a fresh water system. The surrounding alluvial lands are vegetated with a mixture of upland, facultative upland, and facultative species. Species found in this area consist of Indian mulberry (Morinda citrifolia), royal palm, pink trumpet tree (Tabebuia heterophylla), and Panicum sp.

The basin mangrove forest and the surrounding area will be impacted by the proposed Majagual channel improvements and levee borrow channel.

Borrow Areas:

Several borrow sites are being proposed for the construction of the levees. The Western Borrow Area is located south of the Mayaguez Free Trade Zone. This area is made up of Coloso, Toa, and Mani soils. Much of this area is still planted with sugarcane and has been extensively drained and altered. The Eastern Borrow Area consists mostly of abandoned sugarcane fields, with some wetland encroachment. There is a small oxbow pond near the Road 100 bridge. Pond vegetation includes water hyacinth, bamboo, Cyperus sp., Arundo donax and Panicum sp. This pond will be impacted by the proposed borrow area. However, there is the opportunity of enlarging and enhancing the open water habitat after the project is completed. The borrow area east of Road 100 will again affect existing sugarcane fields.

San German:

Flood Control measures in the town of San German include a system of levees through the town to protect it from river flooding. The town of San German has expanded up to the banks of the Guanajibo River.

The municipal government has already begun its own channelization and bank protection project. The existing channel has been widened, and gabion drop structures have been placed along Road 347 in an effort to reduce bank erosion. Wildlife resources in the area are minimal since the surroundings have been developed. Vegetation consists of scattered bamboo clumps and abandoned cattle pasture. The borrow areas in San German are composed mostly of Reilly and Toa soils. Some of these areas are still used as cattle pasture. The western borrow area will have to be changed since a housing development has recently been built in part of the proposed area.

Recommendations:

The Corps should consider the re-alignment of the levee borrow channel. The alignment should follow the course of the existing Sabalos Creek (Figure 2). This would avoid impacts to the adjacent wetlands areas. The proposed mitigation area is a strip along the confluence of the Rio Hondo and Guanajibo. We recommend that this area be extended so that it connects with Caño Corazones. This will provide a continuous wetlands area and provide additional flow into the existing Corazones wetlands (Figure 3). If this is not possible we recommend that the mitigation site be moved nearer the mouth of the Guanajibo so that it is contiguous to existing wetlands.

As proposed, the mitigation site would provide ample area for the planting of Pterocarpus trees. Pterocarpus forests have become an endangered habitat type in Puerto Rico and the expansion or creation would considerably enhance marginal wetlands. These forested wetlands provide habitat for numerous native waterfowl species. Pterocarpus seedlings cannot withstand direct sunlight, therefore we recommend the planting of Anona glabra, Marcharium lunatum, leather fern Acrostichum sp. and white mangrove Laguncularia racemosa to first establish wetland vegetation. Later Pterocarpus seedlings can be planted under the established canopy.

If the mitigation site is moved towards the river mouth (Figure 4) wetland creation as well as enhancement of existing wetlands could be carried out. Mangrove vegetation could be established in the lower portion of the site and Pterocarpus in the upper portion. Existing wetlands would be enhanced by increased flow.

In San German the possibility exists of creating fresh water wetlands from the borrow sites. These areas if properly maintained could be beneficial to wildlife resources.

Over all, the proposed flood control measures will have less impact than the previously proposed measures of channelization. The opportunities for mitigation are numerous and should be exploited to minimize overall loss of wetlands in the project site.



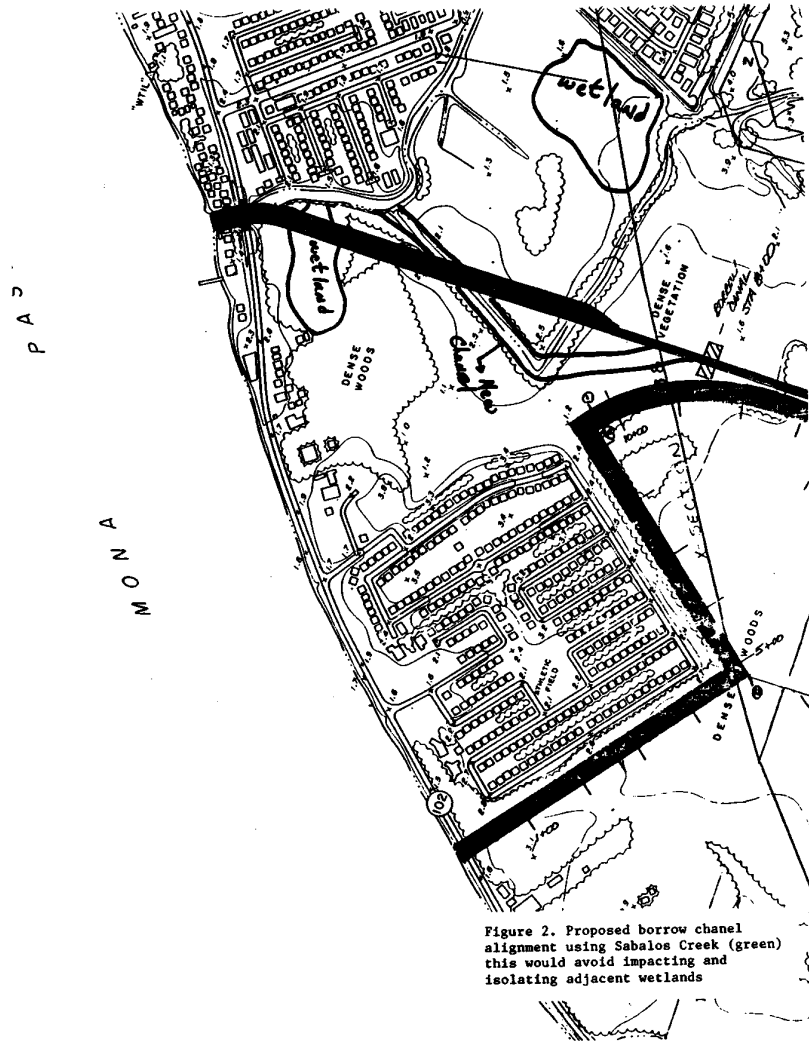
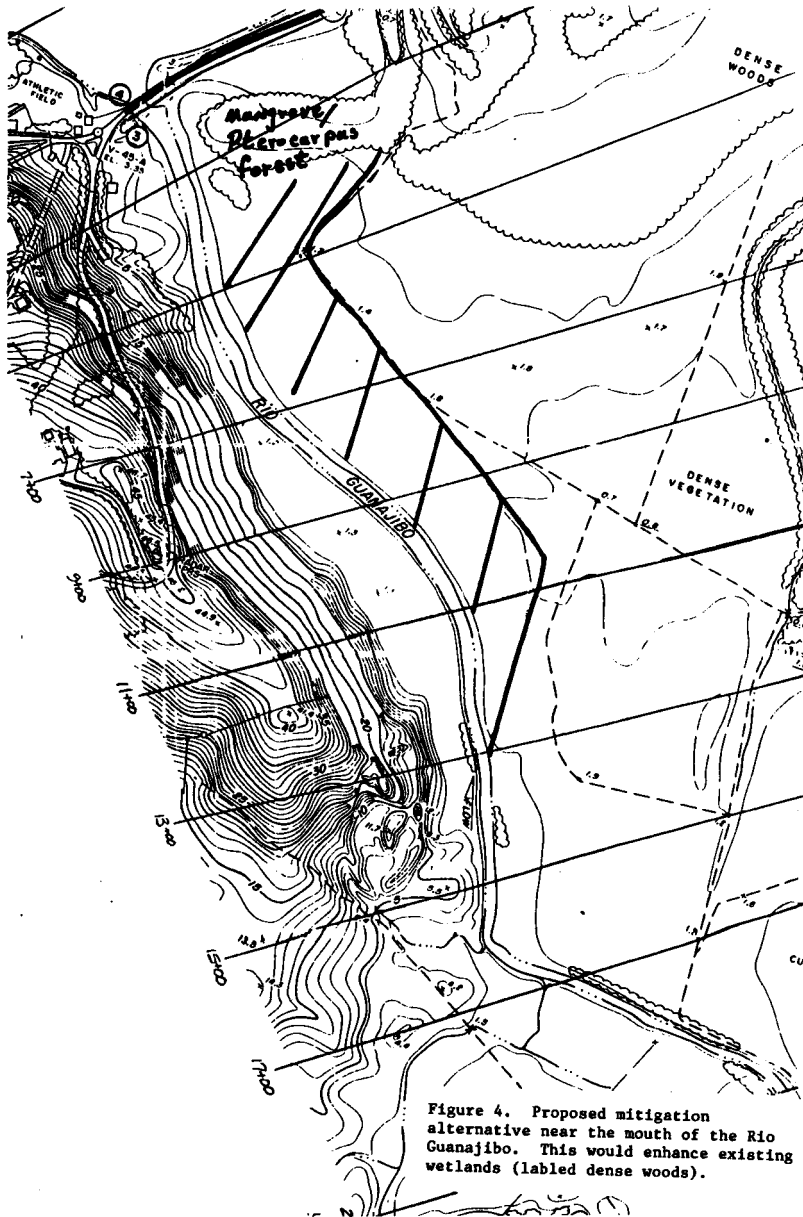




Figure 3. Proposed mitigation alternative with connection to the Caño Corazones wetlands.





United States
Department of
Agriculture

Soil
Conservation
Service

Caribbean Area
P.O. Box 364868
San Juan, PR 00936-4868

September 20, 1994

Mr. A.J. Salem
Chief, Planning Division
U.S. Army-District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

We have completed the Farmland Conversion Impact Rating form
for the Guanajibo project.

If you have questions please contact Mrs. Carmen Santiago
from my staff.

Cordially,

A handwritten signature in dark ink, appearing to read "Roy L. Vick".

ROY L. VICK
Staff Soil Scientist

Enclosure

U.S. Department of Agriculture					
FARMLAND CONVERSION IMPACT RATING					
PART I (To be completed by Federal Agency)			Date Of Land Evaluation Request: <u>8-9-94</u>		
Name Of Project: <u>RIO GUAYAMA FLOOD CONTROL</u>			Federal Agency Requested: <u>US ARMY CORPS OF ENGINEERS</u>		
Proposed Land Use: <u>LEVEES</u>			County And State: <u>PUERTO RICO</u>		
Date Request Received: <u>8-17-94</u>			Date Request Approved: <u>9-20-94</u>		
Does this conversion project involve farmland or local important farmland? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			Acreage Irrigated: <u>0</u> Average Farm Size: <u>85</u>		
If yes, the FPPA does not apply. Do not complete additional parts of this form.			Amount Of Farmland As Defined In FPPA: <u>107,142</u> Acres: <u>24.9</u>		
Formable Land In Govt. Jurisdiction: <u>107,142</u>			Date Land Evaluation Returned By SCS: <u>9-20-94</u>		
PART III (To be completed by Federal Agency)			Alternative Site Rating		
A. Total Acres To Be Converted Directly			Scale: FFS	Site A	Site D
B. Total Acres To Be Converted Indirectly			189.0	141.8	
C. Total Acres In Site			189.0	141.8	
PART IV (To be completed by SCS) Land Evaluation Information					
A. Total Acres Prime And Unique Farmland			137.48	97.96	
B. Total Acres Statewide And Local Important Farmland			1.54	1.54	
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted			2.13%	0.09%	
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value			24.1%	24.1%	
PART V (To be completed by SCS) Land Evaluation Criterion					
Relative Value Of Farmland To Be Converted (Scale of 0 to 100 Points)			71.47	68.32	
PART VI (To be completed by Federal Agency)					
Site Assessment Criteria (These criteria are explained in 7 CFR 658.5(b))			Maximum Points		
1. Area In Nonurban Use			15	7	7
2. Perimeter In Nonurban Use			10	5	5
3. Percent Of Site Being Farmed			20	10	10
4. Protection Provided By State And Local Government			20	0	0
5. Distance From Urban Buildup Area			N/A		
6. Distance To Urban Support Services			N/A		
7. Size Of Present Farm Unit Compared To Average			10	10	10
8. Creation Of Nonfarmable Farmland			5	5	5
9. Availability Of Farm Support Services			5	5	5
10. On-Farm Investments			20	5	5
11. Effects Of Conversion On Farm Support Services			25	0	0
12. Compatibility With Existing Agricultural Use			10	2	2
TOTAL SITE ASSESSMENT POINTS			160	53	53
PART VII (To be completed by Federal Agency)					
Relative Value Of Farmland (From Part V)			100	71.47	68.32
Total Site Assessment (From Part VI above or a local site assessment)			160	53	53
TOTAL POINTS (Total of above 2 lines)			260	124.47	121.32
Site Selected: <u>Site 2+4</u>			Date Of Selection: <u>9-21-94</u>		
Reason For Selection:			Was A Local Site Assessment Used? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		

1
Commonwealth of Puerto Rico
PUERTO RICO AQUEDUCT & SEWER AUTHORITY

August 29, 1994

Mr. A. J. Salas, Chief
Planning Division
San Juan, Puerto Rico
Environmental Resources Branch
Department of the Army
Corps of Engineers
P.O. Box 4976
Jaliscoville, Florida 32212-4919

Dear Mr. Salas:

Re: MAYAGUEZ-HONOLULU
AND SAN GERMÁN, PUERTO RICO
San Juan, Puerto Rico
Environmental Impact Statement (EIS)
BIO GUANAJIBO


In response to your letter dated July 11, 1994, our Office has reviewed the documents submitted and has the following comments:

1. In the Mayaguez area, the Authority has water pipelines around Ramirez de Arellano development that may be affected with the proposed project. Also, in the San Just development area there is a millstone and there are various proposed sewer pipelines that may be affected.
2. In the San Germán area, the Authority has several deep wells that may be affected by the proposed project.

These comments should be considered when designing the project in order to avoid damage to the existing facilities.

We appreciate your interest in consulting us.

Cordially yours,


Bertha Ruiz Soto, Chief
Environmental Evaluation Office

Puerto Rico Aqueduct & Sewer Authority,
August 29, 1994

Response.

1. Replacement of all utilities that would be impacted by the proposed project is the responsibility of the local sponsor. Sewage and water lines impacted by the project have been identified and the cost of relocation included in the project costs. Detailed coordination of the project construction features will be coordinated with the local agencies during the PED Phase of the project.
2. The proposed channel improvements in San Germán will not significantly impact the water table. The channel improvements will be gabion lined, which would not affect infiltration rates. Coordination with PRADA will occur during the PED Phase of the project.

US Department of Agriculture, Soil Conservation Service
September 15, 1994

Caribbean Area
P.O. Box 264868
San Juan, PR 00926-4868

September 15, 1994

United States
Department of
Agriculture
FAX TRANSMITTAL
TO: Caribbean Area
FROM: Planning Division
SUBJECT: 264868-1868
DATE: 9/15/94
TIME: 2:05 PM
PAGES: 2

Response.

Page 22. This error has been noted.

Page 28. This error has been noted.

Page 42. For this report we prefer to use the existing abbreviation.

Page 105. The Colosoide were originally on the hydric soils list. This statement will be corrected to reflect the change in the list. We will consider the use of your replacement for Figure 4-1.

Mr. A.J. Salas
Chief, Planning Division
Environmental Branch
U.S. Army Corps of Engineers
P.O. Box 487
Jacksonville, FL 32223-0019

Dear Mr. Salas:

This letter is in regards to your request for information regarding the Revised Draft Feasibility Report and Draft Environmental Impact Statement for the Rio Guanajibo Project. The comments from the Environmental Agency on references to soils. The following are requested corrections and comments:

Page 22: 5. Soils. "horus" is spelled "horus". Coloso series should read "somewhat poorly drained".

Page 28: C. Land Use. The acreage of wetlands is high and does not agree with the map. Also, see comments on page 105 and Figure 4-1.

Page 42: F. Sediments. The Soil Conservation Service is abbreviated SCS, not USCS.

Page 105: Coloso soils are NOT on the hydric soils list. The Coloso map unit is listed as one that may have hydric inclusions. Coloso soils do exhibit anaerobic characteristics, but are somewhat poorly drained. The soils are not saturated for sufficient duration near the surface to qualify as a saturated hydric soil. If some areas of Cn pond or flood for sufficient duration, then those specific areas would be considered hydric. I believe this would be unlikely for entire delineations of Cn. Tidal swamps (rd) and Alluvial land (An) ARE on the hydric list as hydric soils. I suggest replacement of Figure 4-1 with something reasonable such as I have enclosed.

Page 143: Soils. I would be interested in Mr. Garcia's evaluation that led him to classify Coloso as hydric on the basis of color. Ponding is so far removed from the criteria that will place Coloso as a hydric soil.

Page 144: 5. If "all areas mapped as Coloso soils (Ch) are actively planted and maintained as sugarcane are not currently functioning as wetlands", then they are not wetlands. They meet the LHA criteria as SC prior wetlands. Coloso is the only soil proven to have ponded prior to farming, if not, then they are non-wetlands (NW) or uplands.

Page 145: Site 3, etc. Same comment on soils colors of Coloso as Page 143. These colors are not indicative of hydric soils.

Page 264: D. Soils. The hydrologic group for tea is B, Coloso (not Calosa) is D. Mucara, not Mecara.

If requested, we will assist in evaluating the agricultural lands for official wetland determination. The report states using the 1989 manual for the evaluation. Considering this and the previous errors cited, a new evaluation is indicated.

Sincerely,



Rex L. VICK
Staff Soil Scientist

Enclosure

cc: Juan A. Martinez, Director

Page 143. The determination of the hydric classification was based on field judgement of the wetlands team.

Page 144. You are correct in stating that these are prior converted wetlands.

Page 145. See previous response to Page 143.

Page 264. This error has been noted.

A new wetland delineation is not anticipated because the only wetland impacts are located in mangrove wetlands along the coast. All other areas have been avoided.



OFFICE OF THE GOVERNOR
LA FORTALEZA

Control 94-2468

August 28, 1984

Mr. A. J. Salem
Chief
Planning Division
Department of the Army
Jacksonville District COE
P.O. Box 48770
Jacksonville, FL 32232-0019

SHIPD 11-28-85-01 REVIEW OF DRAFT FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT
STATEMENT (DEIS) FOR THE RIO GUANAJIBO FLOOD CONTROL PROJECT, PUERTO RICO

Dear Mr. Salem:

Our Office has received and reviewed the above mentioned draft EIS. Our comments of June 16, 1987
and May 24, 1989 concerning this project remain in effect (copies attached).

If you have any questions concerning our comments, please contact Mr. Miguel Bonet, State
Archaeologist at our Office. Your interest and cooperation in helping to protect Puerto Rico's
archaeological and historical resources are appreciated.

Cordially,

Rafael Rivera
State Historic Preservation Officer

AP/MB

c Enq. Osvaldo Collazo, COE
San Juan, PR

Enclosures

Office of the Governor
August 28, 1984

No response required.



August 24, 1994

A. J. Salas, Chief
Planning Division
Department of the Army
Jacksonville District
Corps of Engineers
P.O. Box 1000
Jacksonville, Florida 32232-0019

Dear Mr. Salas:

This is in reference to your request for comments on the draft Feasibility Report and Environmental Impact Statement (DEIS) for the Rio Guanajibo Flood Control Project in the vicinity of the Mayaguez-Moragues and San German areas.

According to the report, the flood control measures were evaluated separately for the Mayaguez-Moragues and the San German areas for purpose of optimization of the project. The recommended plan for the Mayaguez-Moragues area includes several structural elements for the protection against the 100 year-flood to developed areas of Guanajibo, San José, Mairaz de Arellano, Valle Meraoso, Buenaventura and San Romulo. The plan provides for a 96 percent reduction of the potential urban flood damages and will protect about 2,234 families. The plan also minimizes the potential environmental impact in the area. The plan is in compliance with the Land Use Plans of both municipalities.

On the other hand, for San German area the recommended plan consists of channel improvements and a bridge at the highway 15 to provide protection against the 100 year-flood. Other plan elements include a levee and a dike against the 100 year-flood and 25 year-flood, however the plan that provides the better benefit-cost ratio of 1.2/1.0 was the 10 year flood plan. The recommended plan will protect about 292 families. The channel improvements design storm will be equal to the level of protection which means that the properties to be protected by the project are still subject to floodplain regulations and flood insurance requirements. We recommend that, in addition to the 10 year-storm design, take into consideration the 100 year flood levels in the design phase of the project in order to increase the level of protection and minimize the 100 year flood impact on adjacent properties.

Cordially,


Boris E. Burgos-Andojar
Chairman

BA/BW/sha

Mayaguez-Moragues Center, North Side
Dr. Diego A. Ruiz 25
P.O. Box 41116, San Juan, P.R. 00940-1116

Puerto Rico Planning Board
August 24, 1994

Paragraph 3. If the local sponsor wishes to pay for the additional design and construction costs associated with the increased level of protection, we would gladly design and construct the locally preferred alternative.



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION II
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, NEW YORK 10278-0012

SEP 01 1994

Mr. A. J. Salem, Chief
Planning Division
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

This is to confirm the August 29, 1994 telephone conversation between William Ponferek and Evelyn Tapani-Rosenthal of our respective staffs regarding the draft environmental impact statement (EIS) for the Rio Guanajibo Flood Protection Project in Mayaguez and San German, Puerto Rico. The Environmental Protection Agency (EPA) requested, and was granted, a two week extension of the comment period for draft supplemental EIS. Accordingly, EPA will submit its comments on this draft supplemental EIS by September 12, 1994.

Sincerely yours,

Robert W. Hargrove
Robert W. Hargrove, Chief
Environmental Impacts Branch

cc: William Ponferek, Corps

The US Environmental Protection Agency
September 1, 1994

An extension was granted to EPA to provide comments by September 1, 1994.



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Miami Regional Office
Southwest Regional Office
9721 Executive Center Drive
St. Petersburg, Florida 33702

US Department of Commerce, National Oceanic and Atmospheric Administration
August 18, 1984

No response required.

August 19, 1984

J. Salem
Chief, Planning Division
Department of the Army, Corps of Engineers
Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

The National Marine Fisheries Service has reviewed the Revised Draft Feasibility Report and Draft Environmental Impact Statement for the proposed Flood Control Study, submitted to us by the Jacksonville District, Corps of Engineers, located in the vicinity of Mayaguez, Homestead, and San Carlos Puerto Rico. To the best of our knowledge, the draft document adequately assesses the project's potential impacts to marine life and resources. We have no comments or suggestions for improvement regarding the project's potential impacts to the marine environment. We have no comments or suggestions for improvement regarding specific recommendations for possible modifications which would eliminate, reduce or compensate for the impacts.

Thank you for the opportunity to review this document. Please continue to apprise us as project plans progress. If you have any questions, please contact Ms. Shelley at 305/595-0392. Sincerely,

Sincerely,

Shelley D. King
b2c
Andreas Rager, Jr.
Assistant Regional Director
Habitat Conservation Division



United States Department of the Interior

OFFICE OF THE SECRETARY

OFFICE OF ENVIRONMENTAL POLICY AND COMPLIANCE

Richard B. Russell Federal Building
150 North Capitol Street, N.E.
Atlanta, Georgia 30303

August 23, 1984

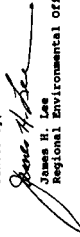
ER-84/580

A. J. Salem, Chief,
Planning Division
U. S. Army Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

The Department of the Interior has reviewed the draft Feasibility Report and Environmental Impact Statement for the Rio Grande Control Study, Rio Guadalupe, Puerto Rico. We have no comments to offer. Thank you for the opportunity to review this document.

Sincerely,


James H. Lee
Regional Environmental Officer

US Department of the Interior, Office of Environmental Policy and Compliance
August 23, 1984

No response required.



United States Department of the Interior

OFFICE OF THE SECRETARY
OFFICE OF ENVIRONMENTAL POLICY AND COMPLIANCE

Richard B. Russell Federal Building
76 Spring Street, S.W.
Atlanta, Georgia 30303

August 25, 1994

ER-94/580

A. J. Salem, Chief,
Planning Division,
U. S. Army Corps of Engineers
P. O. Box 4970
Jacksonville, FL 32212-0019

Dear Mr. Salem:

This is a follow-up letter to the Department's "no comment" response sent to you on August 23, 1994, for the Flood Control Study Rio Guanabara, Rio de Janeiro, Brazil. I hope you will consider the following comments for your final plan.

Mitigation

The Fish and Wildlife Service (Service) comments on mitigation have changed as the project design has evolved throughout the years. The Service's most recent comments of October 1993, recommended a 1:1 mitigation ratio based on the loss of *Pterocarpus* wetlands due to the Cano Majagual channel improvements. The Corps' Addendum to the Draft Feasibility Report states that these channel improvements are being reviewed and will be dropped if not economically justified. The Service's final recommended mitigation strategy will depend on this decision.

The proposed mitigation plan (Exhibit V, DEIS) calls for a 1:1 ratio consisting of the acquisition of 22.5 acres of land to be planted and left to natural colonization. Rather than leaving the area to natural succession, we believe that planting of black and white mangrove seedlings, together with the seeding of black and white mangrove seeds would better ensure success. If the Corps would like to leave the area to natural revegetation, then a greater than 1:1 mitigation ratio should be considered.

We agree with the Habitat Enhancement Opportunity presented in Part 7 of the mitigation plan. However, due to the experimental nature of planting *Pterocarpus* and freshwater forested wetlands creation, this area should be strictly in addition to the regular mitigation.

US Department of the Interior, Office of Environmental Policy and Compliance
August 25, 1994

Response:

Mitigation:

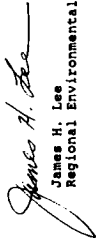
We have revised the mitigation plan to include seeding of the area as recommended by your agency. Therefore, no increase in the mitigation ratio is necessary.

The creation of the *Pterocarpus* area will be evaluated during the PED Phase of the project.

Once a mitigation plan is decided upon, the grading and actual construction should be carried out in the planning and specification stage. A final mitigation plan, complete with as built engineering drawings, should be reviewed by the Service prior to final approval.

Thank you for the opportunity to provide comments.

Sincerely,



James H. Lee
Regional Environmental Officer

US Department of the Interior, Office of Environmental Policy and Compliance
(cont)

We will coordinate the final mitigation plan prepared during the design phase of the project with the Caribbean Field Office.



United States Department of the Interior

FISH AND WILDLIFE SERVICE
(Caribbean Field Office)
P.O. Box 481
Barrington, Puerto Rico 00622



US Department of the Interior, Fish and Wildlife Service
August 18, 1994

Please refer to the previous responses from the Office of Policy and Compliance.

August 18, 1994

Mr. A.J. Salem
Chief, Planning Division
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232

Re: Rio Guanajibo Flood Control

Dear Mr. Salem:

We have reviewed the Draft Feasibility Report and DEIS for the proposed Guanajibo Flood Control Project. The Service has been working closely with the Corps in the planning phase of the project. After a careful review we have the following comments:

Mitigation Plan:

The Service's comments on mitigation have changed as the project design has evolved throughout the years. The Service's most recent comments of October 1993, recommended a 3:1 mitigation ratio based on the loss of *Etiocarpus* wetlands from the proposed Caño Majagual channel improvements. The Corps' Addendum to the Draft Feasibility Report states that these channel improvements are being re-evaluated and will be dropped if not economically justified. The Service finds that the economic justifications on the proposed mitigation strategy will depend on the Corps' decision.

The proposed mitigation plan (Exhibit V, DEIS) calls for a 1:1 ratio consisting of the acquisition of 22.5 acres of land to be graded and left to natural colonization. Although a 1:1 ratio could eventually compensate for the loss of wetlands impacted, very few wetland creation plans are 100% successful. The wetlands being impacted are mangrove forests which have a very low natural regeneration rate. It would take 30-50 years for the trees in the mitigation area to reach the same height and diameter. A ratio of 1.5:1 would compensate for the loss of habitat and services provided by that habitat and reflect the delay in reaching the desired wetland system. Leaving the area to natural revegetation could result in the area being invaded by fast growing weedy species that would slow colonization by mangroves and other preferred vegetation. This

US Department of the Interior, Fish and Wildlife Service (cont).
Please refer to the previous response from the Office of Policy and Compliance.

would lower the habitat value of the area over a longer period of time. Rather than leaving the area to natural processes, we believe that planting of black and white mangrove seedlings and broadcasting of black and white mangrove seeds would better insure success. If the Corps wishes to leave the area to natural revegetation then a greater than 1:3:1 mitigation ratio should be considered since it would take much longer for the area to be colonized by wetland vegetation.

We agree with the Habitat Enhancement Opportunities presented in Part 7 of the Mitigation plan. However due to the experimental nature of planting *Elaeagnus* and the creation of freshwater forested wetlands, any effort in this area should be strictly in addition to the regular mitigation.

Once a mitigation plan is decided upon, the grading and actual construction should be calculated during the Planning and Specification Phase of the Mitigation plan complete with as built engineering drawings should be reviewed by the Service prior to final approval.

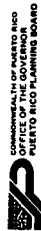
If you have any questions please contact Felix Lopez at 809-851-7297.

Sincerely,


Susan Sillader
Acting Field Supervisor

fhl

cc: DNR, San Juan
COE, San Juan
EPA, New York
FWS, San Juan
CZM, Washington, DC
NMFS, Panama City
EQB, Terrestrial Ecology Division
PRPB, San Juan



Planning Board
 Planning Board
 P.O. Box 4111, San Juan, P.R. 00940-0000

Puerto Rico Planning Board
 August 3, 1994

No response required.


August 3, 1994

Mr. A.J. Salas
 Chief, Planning Division
 Department of the Army
 Jacksonville District Corp of Engineers
 P.O. Box 4970
 Jacksonville, Florida 32232-0019
 Environmental Impact Statement
 Flood Control for the San Juan River
 and its Tributaries of Mayaguez
 Bormigueros and San German

Dear Mr. Salas:

Our Agency has received and reviewed the above referenced Environmental Impact Statement and we do not have any objections to the document.

Sincerely,


 Norma Burgos Andujar
 Chairwoman
 ALV/MCC/ees

Ref. No. _____

August 16, 1994

Mr. A. J. Sales
Chief, Planning Division
Department of the Army
Jacksonville District Corps of Engineers
P. O. Box 4976
Jacksonville, FL 32232-0010

RIO GUANAJIDO FLOOD CONTROL PROJECT

Dear Mr. Sales:

This is in regard to your letter-- referred to the project of reference.

Our technicians have studied the documents, and their opinion is that the recommended plan or program presented would benefit the production of life in the area. During tropical storms "Eloise" in 1975 and "Gladys" in 1976, the area suffered excessive rainfall and flooding. Our technicians, former governor Man, Carlos Rosendo Barceld must be in the Corps of Engineers to initiate the studies for the entire Guanajibo River Basin under the Cooperative Study Program.

We concur with the selected plan, and thank you for the opportunity to comment.

Sincerely yours,

Matos
Raimundo Matos Iglesias
Executive Director

PUERTO RICO ELECTRIC POWER AUTHORITY
350 Ave. Puerto Rico

San Juan, Puerto Rico



P.O. Box 348267

P.O. Box 346267
San Jose, Costa Rica 20034-6267

Puerto Rico Electric Power Authority
August 16, 1984

August 18, 1994

No response required.

August 16, 1994

Mr. A. J. Salem
Chief, Planning Division
Environmental Resource Branch
Department of the Army
Jacksonville District,
Corps of Engineers
PO Box 4978
Jacksonville, Florida 32232-0019

Dear Mr. Solent:

**Re: Draft Feasibility Report and
Environmental Statement (DEIS)
Rio Guanajibo, Puerto Rico**

We have revised the DEIS included in your letter of July 11, 1994.

PREPA has no issues of environmental significance to comment on the above mentioned document.

Should this project requires the relocation of electrical pole lines, then we recommend you contact our Mayaguez Area Engineer, Victor Ruiz at telephone (809) 832-7734.

Cordially,

Angel L. Rivera Santana
Director, Planning and
Environmental Protection



COMMONWEALTH OF PUERTO RICO
PUERTO RICO INDUSTRIAL DEVELOPMENT COMPANY
PO BOX 32230 SAN JUAN PR 00932-2330

Puerto Rico Industrial Development Company
August 23, 1994

FAX (809) 250-1

No response required.

August 23, 1994

Department of the Army
Jacksonville District Corps
P. O. Box 3400
Jacksonville, Florida 32232-0010

Attention: Mr. A. J. Salem
Chief, Planning Division
Environmental Studies Section

Dear Mr. Salem:

Re: Draft Supplemental Environmental Impact
Statement for the Rio Guanajibo flood control
Project in the vicinity of the Mayaguez,
Hormigueros and San Germán areas

Reference is made to your notice of July 11, 1994, related to the
Project report mentioned above.

The Puerto Rico Industrial Development Company endorses this
Project. We consider that the attached draft of the environmental
impact covers the most important details.

Thanks for taking into consideration our original comments
regarding it.

Cordially yours

Andrés Gómez Alayón

Andrés Gómez Alayón
Acting Vicepresident for Development



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION II
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, NEW YORK 10278-0012

SEP 12 1984

Mr. A. J. Salem, Chief
Planning Section
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Class: EC-2

Dear Mr. Salem:

The Environmental Protection Agency (EPA) has reviewed the draft environmental impact statement (EIS) for the Rio Guanajibo Flood Protection Project, in Mayaguez and San German, Puerto Rico. This review was conducted in accordance with Section 309 of the Clean Air Act, as amended (42 U.S.C. 7609, PL 91-604 12(a), 84 Stat. 1709), and the National Environmental Policy Act.

The draft EIS evaluates several plans proposed by the U.S. Army Corps of Engineers (ACE) to provide flood protection to urban areas along Rio Guanajibo. The recommended plan includes a levee and floodwall system to provide the Mayaguez-Hormiguero area protection against the 100-year flood; proposed channel improvements, including bridge replacement; would provide the San German area protection against a 10-year flood. Based on our review, we offer the following comments.

The draft EIS indicates that permanent evacuation of the flood plain areas is "impractical and would have very little acceptance" and, therefore, was not considered as a reasonable alternative. Although we do not disagree with this conclusion, the document does not provide sufficient information to support it. Moreover, considering the comments made in the draft EIS, it is recommended that the Corps conduct a Floodplain Management Review Committee Report. Sharing the Challenged Floodplain Management into the list Summary, focus on a floodplain management strategy that emphasizes consideration of nonstructural alternatives, we request that a more complete discussion of the feasibility of partial or complete evacuation, and other nonstructural alternatives, be included in the final EIS.

The document notes that the Rio Guanajibo flows through mostly agricultural areas of the floodplain where herbicides and pesticides are used. Since the recommended plan includes channel improvements and channel clean out, we believe there is a high potential for encountering contaminated sediment during

US Environmental Protection Agency
September 12, 1984

Response.

Paragraph 3. Do not concur. In a preliminary evaluation of the non-structural methods especially evacuation, it was determined that these alternatives were economically prohibitive. The cost of real estate, relocation and infrastructure cost were in excess of \$250 million.

Paragraph 4. Do not concur. A visual reconnaissance of the area was performed with negative results and no indication of contamination was found at the time. In response to the poor water quality issue, a reference made, of the USGS publication "Water Resources Data Puerto Rico and the U.S. Virgin Islands, Water Year 1983", for the project area with the following results:

a. One pesticide was found in concentrations high enough to be detected, 2,4-D, which was found at 6.08 ug/L. This concentration is well below the ECB water quality standard of 100 ug/L. No other pesticide was detected above MDL's.

b. The data shows concentrations of manganese and iron over the limits established by Puerto Rico Water Quality Standards, for the SD class. If sediments are going to be removed from the bottom of the river waters they should be tested randomly in the preconstruction phase for heavy metals content in order to evaluate the possibility of sediments as a source of this contamination and to determine the appropriate disposal method.

c. As existing concentrations of contaminants in the water column were above ECB standards we concluded "the health of the river was poor."

The water turbidity in the area for the period (October 82 to September 1983) was in average well below the standard (50 NTU). Short term increases in turbidity are expected due to construction activities. All appropriate measures required by Puerto Rico Environmental Quality Board regulations would be adopted. It is believed that conditions will return to normal soon after construction activities have terminated. The Corps routinely experiences short term turbidity fluctuations during construction. Turbidity screens and controls will be specified during the construction phase and sediment control plans will be generated by the Contractors performing the work as necessary. No other mitigation for turbidity should be planned.

Paragraph 5. We do not concur that the potential for contamination is high however we will recommend (during PED) random sampling of the sediments in conjunction with heavy metal studies recommended above. The following parameters will be tested for:

- a)- PESTICIDES-SW 846 EPA Method 8270
- b)- Herbicides-SW 846 EPA Method 8150
- c)- Heavy Metals-SW 846 EPA Method 8005
- d)- RCRA Metals-Appendix II to Part 261 40 CFR.

In the unlikely event that contaminated sediments are found a plan for disposal of contaminated sediments (exceeding regulated limits) including disposal in an upland disposal site (Landfill) will be generated.

Paragraph 6. The mitigation process was detailed in the Selected Mitigation Plan Exhibit V. Since the coordination of the DEIS, the improvements at Cano Maigual has been dropped. This would reduce mangrove impacts by 0.91 acre and eliminate all impacts to the cattle wetlands. Another minor change is the shifting of the levee behind Guanabito Homes Subdivision in order to protect the local radio station. By doing so the levee would isolate 6.0 acres of mangroves. Over time this area would become less saline and there would be a gradual transition to a freshwater environment with a loss of these mangroves. Later in the PED phase the design of the culvert used to drain residual flooding from behind the levee will be evaluated to determine if it would be feasible to allow saline tidal flows to flush this area preserving the mangroves. Otherwise this area is being considered a loss. Considering all of the above the new total of wetlands affected would be 27.6 acres of mangroves. During the study process and Fish and Wildlife Coordination Act report preparation, no concerns were expressed for loss of value during the mitigation area construction and reclamation. This is mostly due to the site location in the tropics where vegetation growth is rapid. During this period the mitigation area would have wildlife value as it goes through various successional stages from mud flats to scrub-shrub to forested wetlands. In addition the 6 acre tract of mangroves would remain intact for many years while the mitigation area is being revegetated. Therefore, there would be no loss of value during this time frame.

Paragraph 7. The final levee design was not selected until prior to publication of the DEIS. The Prime Farmland Rating will be included in the final report.

Paragraph 8. In San German the channel improvements would only provide a 10-year level of protection, therefore, this part of the project would not induce any development. The only place the levees would encroach on the floodplain area would be from the Rio Hondo upstream. However, no induced development would occur because the areas behind the levees would store the residual flooding rainfall from the upland areas.

construction. Accordingly, excavated sediment generated from this action must be evaluated for the presence of hazardous contaminants prior to disposal. Similarly, although the draft EIS states that the water quality is poor, documentation was not provided to support this conclusion. Furthermore, the document acknowledges that the project will cause turbidity impacts to the river, but does not propose a mitigation plan to offset these impacts. In addition, the draft EIS states that the project should present a detailed sediment control plan to assure that the existing poor water quality is not exacerbated.

In a related matter, the evaluation for hazardous and radiological waste along the project corridor was only a level-1 survey that did not include soil sampling. Given that portions of the project corridor are in industrialized and agricultural areas, the final EIS should provide a more definitive characterization of the possibility of encountering contaminated soils during project construction, and identify a plan for contacting materials disposal, as well as health and safety protection plan for the workers and general public.

With regards to wetlands, the document states that 22.5 acres of mature mangrove forest and 4.6 acres of cattail wetlands would be lost because of this project. Measures to avoid or minimize project impacts are not discussed; this information must be included in the final EIS. Furthermore, the plan to mitigate unavoidable wetlands impacts should be expanded. Specifically, three mitigation alternatives are presented to provide 111 acreage replacement of the 22.5 acres of mangroves that would be impacted by the project. These proposals include: (1) replanting the mangroves with native species; (2) replanting with mangroves; or (3) planting of a bottomland species off site. While the first two alternatives may lead to eventual mangrove colonization, the process would take years, so the current colonization and values of the mangrove forest would not be replaced for some time. In addition, the areas may be colonized by wetland grasses, which are not as valuable. Furthermore, mitigation plans for cattail wetlands loss also provide only a 111 acreage replacement. With this in mind, the final EIS must provide a more comprehensive mitigation plan to ensure 111 value replacement, rather than the proposed 111 acreage replacement for the mature mangrove forest and cattail wetlands.

The draft EIS does not present an adequate analysis of the proposed project's impacts to agricultural lands. Moreover, the U.S. Department of Agriculture's Farmland Conversion Impact Rating of the project was not provided in this document. Given that the project area is predominantly agriculturally developed, and considering that 11.6 acres of farmland will be lost as a result of this project, the document should include the final EIS provide impact measures to minimize and mitigate any adverse impacts to farmlands.

According to the draft EIS, no adverse cumulative effects are expected as a result of this project. However, given the fact that this project will provide protection for the Mayaguez-Hornigueros area from a 100-year flood event, it has the

Paragraph 9. We will include the appropriate changes in the final EIS.

potential to induce unplanned growth and development in the floodplain area. Therefore, we request that the ACF provide a comprehensive evaluation of secondary impacts, including appropriate mitigation measures, in the final EIS.

Based on our review, and in accordance with EPA policy, we have rated this draft EIS as EC-2, indicating that we have no major environmental concerns (EC) about the proposed project's non-structural alternatives evaluation; soil, sediment, and water quality impacts; hazardous substance identification and management; wetlands impacts and mitigation plan; agricultural impacts; and cumulative impacts. Accordingly, we request that additional information (2) be presented in the final EIS to address these issues.

If you have any questions about this letter, please contact Evelyn Tapani-Rosenthal of my office, at (313) 264-6614.

Sincerely yours,

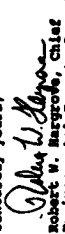

Robert W. Sawyer, Chief
Environmental Impacts Branch
cc: W. Fonferok

TABLE 1-7. RELATIONSHIP OF SELECTED PLANS TO FEDERAL ENVIRONMENTAL PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS
RIO GUANAJOBLO FLOOD CONTROL STUDY, MAYAGUEZ AND SAN GERMAN, PUERTO RICO, 1981

Federal Statutes	Plan 1 & 3		Plan 2 & 4	
Archaeological and Historic Preservation Act, as amended, 16 U.S.C. § 353	Partial ¹		Partial ¹	
Clean Air Act, as amended, 42 U.S.C. 7401 et seq.	Full		Full	
Clean Water Act, as amended, 33 U.S.C. 1251 et seq.	Partial ²		Partial ²	
Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 et seq.	Full		Full	
Federal Protection Policy Act, 7 U.S.C. 4201, et seq.	Full		Full	
Federal Water Project Recreation Act, as amended, 16 U.S.C. 4601-12 et seq.	Full		Full	
Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661 et seq.	Full		Full	
National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321 et seq.	Full		Full	
National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq.	Partial ¹		Partial ¹	
Executive Order				
Floodplain Management (E.O. 11988)	Full		Full	
Protection of Wetlands (E.O. 11990)	Full		Full	

NOTES: For each item listed enter one of the following:

- a. **Full Compliance.** Having met all requirements of the statute, E.O., or other environmental requirements for the current stage of planning (either pre-authorization or post-authorization).
- b. **Partial Compliance.** Not having met some of the requirements that normally are met in the current stage of planning. Partial compliance entries should be explained in appropriate places in the report and/or EIS and referenced in the table.
 1. An archeological survey of the impact area will be conducted prior to construction with the results coordinated with the State Historic Preservation Officer. Any mitigation requirements will be coordinated with and approved by the SHPO which will bring the plans into full compliance.
 2. A Section 404(b) evaluation of the selected plan is attached to this FEIS, and all plans will be in compliance following issuance of Water Quality Certification by the State.

1.0 National Environmental Policy Act of 1969, as amended. This document has been prepared in accordance with CEQ regulation CFR 1500 and Department of the Army Regulation ER 200-2-2. Scoping was conducted notifying the Commonwealth, Federal agencies and members of the public of our intentions to study flooding problems within the Rio Guanajibo Basin at San German and Mayaguez. The Draft EIS was circulated for a period of 45 days and a Notice of Availability was published in the Federal Register dated 15 July 1994. The Final EIS will be circulated for a 30-day comment period before it is filed with EPA. A Record of Decision will be prepared prior to completion of the NEPA process.

2.0. Endangered Species Act of 1973, as amended. A review of the Southeast U.S. Endangered and Threatened Species List, published by the USFWS, revealed the following species could frequent or reside in the project area:

Yellow-shouldered blackbird.....	<u>Agelaius xanthomus</u>
Arctic peregrine falcon.....	<u>Falco peregrinus tundrius</u>
Puerto Rican whip-or-will.....	<u>Caprimulgus noctitherus</u>
Bariaco.....	<u>Trichilia triacantha</u>
West Indian manatee.....	<u>Trichechus manatus</u>
Brown pelican.....	<u>Pelecanus occidentalis</u>

Consultation with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) for the purpose of determining if there is any potential impact on threatened or endangered species or critical habitat was conducted, and Exhibit IV contains the Section 7 consultation correspondence. Of these species only the manatee and brown pelican are known to inhabit the area. Endangered West Indian manatees are frequently observed in the mixing zone at the mouth of the river, and after heavy rains, they ascend the river for short distances, perhaps attracted by water hyacinths washed down in the floods. The brown pelican is known to nest along the shoreline in the Industrial Park near the mouth of the Rio Guanajibo. A No Effect determination was reached by the Jacksonville District Office and concurred with by the USFWS and the NMFS.

3.0. Fish and Wildlife Coordination Act of 1958, as amended (Exhibit VI).

3.1. The project has been thoroughly coordinated with the US Fish and Wildlife Service. A Fish and Wildlife Coordination Act Report were transmitted to this office by letter dated 13 October 1993. Based on the reformulation of alternatives, the US Fish and Wildlife Service was requested to review alternatives and provide additional information in the form of an updated FWCAR. The following recommendations were made:

- a. The selection of M-8 as the preferred alternative.

Response: Concur.

- b. Mitigation for mangrove losses should be at a 3:1 ratio.

Response: Do not concur. Mangrove species in the tropics grow at a high rate. The amount of productivity lost during the recolonization of the mitigation area over a 30-year period (age of the current plants) would not be equal to 3 times the 27.6 acres affected. This ratio was based on potential impacts to mangroves and *Pterocarpus sp.* located near the mouth of the Caño Majagual. The channel improvements at Caño Majagual have been dropped from the project.

- c. A mixture of black and white mangroves should be planted along with leather fern and other wetland vegetation.

Response: Even though the latest technology states that if the mitigation site is located adjacent to the seed sources, planting and/or seeding is not necessary. We will broadcast seeds throughout the mitigation area to provide a greater level of certainty that the proposed colonization would occur.

- d. Channel improvement of Caño Majagual should stop north of Quebrada Sabalos.

Response. The channel improvements have been dropped from the project.

- e. The Puerto Rico Highway Authority is planning a by-pass in the Mayaguez project area. Request that the Corps coordinate this project with them so that the two projects do not conflict.

Response: Concur.

- f. Submit a final mitigation plan to the USFWS during the design phase and coordinate with other resource agencies.

Response. Concur.

3.2. The changes to the project have been coordinated with the USFWS by Telefax dated 28 June 1994 and 18 August 1994. The USFWS responded by letter dated 18 August 1994 providing the following comments:

- a. If the Corps decides to leave the area naturally revegetate than, a 1.5: 1 mitigation ratio is requested.

Response. In order to provide a greater degree of certainty concerning the revegetation, the Corps will broadcast mangrove seeds in the mitigation area.

- b. The USFWS agrees with the Habitat Enhancement Opportunities presented in Part 7 of the Mitigation Plan concerning the experimental planting of *Pterocarpus*

and creation of a freshwater forested wetland.

Response: None required.

c. A final mitigation plan should be coordinated with the USFWS.

Response: Concur.

3.3. A response dated 7 September 1994 was sent to the USFWS detailing these answers. By letter dated 19 September 1994 the USFWS responded agreeing with the mitigation plan as described in Exhibit V. The USFWS recommended minimizing impacts to the 6-acre mangrove tract by evaluating other alternatives to the levee around the radio station and to discuss this in the Final EIS.

Response: The Corps has considered ways to minimize impacts on this 6-acre tract. The most viable may be the conversion of a gated culvert to allow tidal flushing of this area. This has been discussed in the mitigation plan. The engineering evaluation of this area will be done in the Preconstruction Engineering and Design Phase (PED) and the design of this and the mitigation will be coordinated with the USFWS.

4.0. National Historic Preservation Act of 1966, as amended (PL 89-655). Cultural resource study and coordination with the SHPO is in compliance with Section 106 of the National Historic Preservation Act of 1966, as amended, the Archeological and Historic Preservation Act, and Executive Order 11593.

5.0. Clean Water Act of 1972, as amended.

5.1. Section 401. State Water Quality Certification (WQC) will be sought from the Commonwealth of Puerto Rico prior to construction. The project meets the exemption criteria of Section 404(r) of the Clean Water Act for obtaining WQC, and if the Commonwealth is unwilling or unable to issue WQC in a timely manner these provisions will be asserted.

5.2. Section 404. The purpose of Section 404(b)(1) of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the waters of the United States through the control of discharges of dredged or fill material. Controls are established through restrictions placed on the discharges in Guidelines published in 40 CFR 230.

5.2.1. Wetlands Delineations. An interagency survey was conducted in January 1990 to identify and assess any wetlands within the project area (Exhibit II and III). The techniques used were the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (FICWD, 1989) and the Wetlands Evaluation Technique (Adamus, 1987).

Participants were from the USFWS, a private consultant on soils, and the Corps of Engineers. Obvious wetland areas were the mangrove forests, *Pterocarpus* swamp, and other areas labeled Tidal Swamp (Td) or Alluvial Lands (An) on the USDA/SCS soil maps. Wetland delineations within the study area are shown in Figure 4-2. No wetlands were found in San Germán project area.

5.2.2. Based on the probable impacts addressed in the Section 404(b)(1) Evaluation (Exhibit I), compliance with the restrictions, and all other information concerning the fill material to be used, the proposed work has been determined to comply with the Guidelines and the intent of Section 404(b)(1) of the Clean Water Act. State Water Quality Certification (WQC) will be sought from the Commonwealth of Puerto Rico prior to construction. The project meets the exemption criteria of Section 404(r) of the Clean Water Act for obtaining WQC, and if the Commonwealth is unwilling or unable to issue WQC in a timely manner these provisions will be asserted.

6.0. Clean Air Act of 1972, as amended. The Mayaguez area of Puerto Rico is an attainment area for the criteria pollutants under the Act and is not governed by a State Implementation Plan (SIP). Since the project area is within an attainment area, the EPA rules for conformity determination do not apply. No air quality permits will be required for this project. The DEIS will be coordinated with the Air Quality Area, Puerto Rico Environmental Quality Board. Therefore, this project is in compliance with the Act.

7.0. Coastal Zone Management Act of 1972, as amended. The project has been evaluated in accordance with Section 307 of the Coastal Zone Management Act. It has been determined that the project would have no unacceptable impacts and would be consistent with the Plan. Construction in the coastal zone would include the levees and floodwalls around San José Homes and Guanajibo Homes Subdivisions. The DEIS has been coordinated with the Environmental Quality Board. The project is in partial compliance with the Act.

8.0. Farmland Protection Policy Act of 1981. The project has been coordinated with the US Department of Agriculture, Soil Conservation Service, and they have determined that certain soil types within the Río Guanajibo floodplain project boundaries are Prime Farmland (PRDA, 1990). A Site Assessment of the Prime Farmland to be directly affected by the construction of levees and the borrow area has been conducted in accordance with Public Law 97-98 (EC 1105-2-140) using the criteria set forth in 49 CFR 658.5(b)(1-12). The Farmland Conversion Impact Rating Form (AD-1006) was sent to the San Juan Office, Soil Conservation Service, by letter dated 9 August 1994 for their input. By letter dated 20 September 1994, the SCS stated that 97.9 acres of prime farmland would be affected by the preferred alternative (Exhibit VII).

9.0. Wild and Scenic River Act of 1968, as amended. No designated Wild and Scenic river reaches will be affected by project related activities. This act is not applicable.

10.0. Marine Mammal Protection Act of 1972, as amended. The work was coordinated with the US Fish and Wildlife Service during the scoping period and during Section 7 Consultation pursuant to the Endangered Species Act. The West Indian manatee could be located in the project area, but would not be affected.

11.0. Estuary Protection Act of 1968. This act does not apply.

12.0. Federal Water Project Recreation Act, as amended. Recreation development is authorized and permitted at local flood control projects under Section 4 of the 1944 Flood Control Act, as amended and is further affected by the Land and Water Conservation Fund Act, the Federal Water Project Recreation Act (P.L. 89-65) and the Water Resources Development Act of 1986. No recreational facilities are being proposed in conjunction with this project.

13.0. Resource Conservation and Recovery Act (RCRA) of 1976, (PL 94-580; 7 U.S.C. 100, et seq). The objective of this law is to track hazardous toxic and radiological waste (HTRW) from the time of generation to disposal. The law requires safe and secure procedures to be used in treating, transporting, storing and disposing of hazardous wastes. RCRA is designed to prevent new uncontrolled HTRW sites. It also covers storage and transportation of all identified wastes for disposal during construction of this project. Should HTRW be found during construction of this project, it would be disposed of in accordance with all Federal, state and local regulations. At this time no contaminated sites have been identified.

14.0. Toxic Substances Control Act of 1976, (PL 94-469; U.S.C. 2601, et seq. An initial map reconnaissance of the project area, a review of available literature, and a site visit showed no indications of HTRW contaminants within the project corridor. Areas of concern may include the industrial area adjacent to the Río Hondo in Mayaguez, two gasoline station located adjacent to the PR Highway 119 Bridge in San Germán and an abandoned waste water treatment facility located adjacent to Caño Corazones and the Guanajibo Homes Subdivision. No levees would be constructed adjacent to the industrial area near the Río Hondo and the channel work in San German would avoid the gasoline stations. Therefore, the project is in compliance with the Act.

15.0. Archeology and Historic Preservation Act (PL 93-291). The project area has been investigated and no cultural resources have been identified that could be affected by the proposed work. This project has been coordinated with the State Historic Preservation Officer.

16.0. E.O. 11990, Protection of Wetlands. The objective of the Executive Order is to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative.

16.1. The proposed levee construction will eliminate 27.6 acres of mangrove.

16.2. There would be no practicable alternatives to the placement of fill for the levees that would have less adverse impacts and would not affect wetlands for most segments. The construction of a floodwall upland around San José Homes was determined to be a practicable alternative to the originally proposed levee in the mangrove wetlands. All project features have been shifted to avoid to valuable mangroves in Cano Corazones and Cano Majagual.

16.3. The adverse impacts of the selected plan have been offset by the creation of 27.6 acres of mangrove.

16.4. The selected plan has been evaluated in light of Executive Order 11990 on Protection of Wetlands. The project's minimal impacts on wetlands would be offset by the creation of wetlands within the floodplain. Therefore, the project would be consistent with the goals and intent of the Executive Order.

17.0. E.O. 11988, Floodplain Management. The objective of this Executive Order is to avoid to the extent possible the long and short term adverse impacts associated with occupancy and modification of the floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative.

17.1. The selected plan would occur in a flood plain.

17.2. There are no practicable alternatives to the selected plan, and the selected plan cannot occur outside the flood plain.

17.3. The proposed modification of the floodplain will not induce development of the floodplain because the backside of the levee will be used to store localized stormwater runoff. There will be an unavoidable loss of 141.8 acres of Prime Farmland in the floodplain and 27.6 acres of mangrove wetlands. However, the loss of mangrove wetlands will be offset by the creation of a 27.6 acres of mangroves.

17.4. Therefore, the Selected Plan is consistent with the objectives of Executive Order 11988 on Flood Plain Management.

RIO GUANAJIBO FEASIBILITY REPORT**Appendix D
Coordination****TABLE OF CONTENTS**

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RIO GUANAJIBO FEASIBILITY REPORT

APPENDIX D
COORDINATION

A. Introduction

The purpose of this appendix is to document the public involvement and coordination process that underlines this feasibility report. Focus is on the coordination with municipal, state, and other Federal agencies, the public meetings for the general public participation, and the support from the local sponsor and residents of the area.

B. Coordination of Study

To initiate study process, a public meeting was held on August 19, 1980, at 7:30 p.m., in San Germán. A transcript of the meeting is available at the Antilles Office. The public meeting to present study results and recommendations was held on August 23, 1994, in San Germán and in the Mayagüez-Hormigueros area.

At the request of the Puerto Rico Planning Board (PRP), the Department of Natural and Environmental Resources (DNER), and the municipal governments of the study area, review and comment on over 30 design and environmental documents relating to potential projects in the vicinity of Río Guanajibo.

In several meetings and telephone conversations discussed with DNER and PRPB potential flooding impacts of proposed flood control project.

In about 10 occasions accompanied DNER and Fish and Wildlife Service (FWS) staff to the field to check on alignment of proposed measures, mitigation areas, borrow and disposal areas, areas to be protected.

In about 5 occasions visited field with DNER staff to check on implementation of gabion-lined wall along Río Guanajibo in the vicinity of San Germán.

During the past 7 years participated in the annual meeting of Asociación Pro Damnificados Huracán Eloísa in San Germán. This organization associates residents (over 200 families) in the San German area affected by floods from Hurricane Eloísa in September 1975.

During periodical meetings provided Secretary of DNER and his staff status reports on study issues and progress.

In several occasions provided developers in the area and the general public information on the plans being considered and their most probable environmental impacts.

In 3 occasions visited area with WES personnel to delineate wetlands in the area and to examine potential of significant sediment accumulations in the flood plain during flood events.

C. Public Meeting Summary

For purpose of reaching out to more public, two public meetings for the Río Guanajibo Feasibility Report were held on August 24, 1994. One was held in the afternoon in the town of San Germán and the other in the evening at the Valle Hermoso community center. Both meetings were conducted in Spanish. Some 60 persons from the San Germán community participated in the meeting, while 50 persons from the Mayagüez-Hormigueros area participated in the one at Valle Hermoso.

The meetings were co-chaired by Lt. Col. Stephen R. Benton, Deputy District Engineer for the Antilles; Mr. José A. Martínez, Chief, Planning Section; and Mr. Julio F. Dumois, Assistant Manager, Hydrological and Mineral Resources, DNER, project sponsor. Other members of the U.S. Army Corps of Engineers participating in the meeting were: Messrs. A.J. Salem, Chief, Planning Division, and Alberto González, Planning Division, Jacksonville District; Roberto Cortés Colón, Planning Section, study manager, and Mrs. Elsa Jiménez, Public Affairs Office, Antilles Office. Both meetings were attended by an official delegate from the Office of the Governor of Puerto Rico, representative from local municipal government and Federal agencies (U.S. Fish and Wildlife Service, U.S. Soil Conservation Service, etc.). Messrs. Aníbal Lugo Ramírez, Soil Conservation Service, and Jorge López Zapata, president of the Asociación Pro Damnificados Huracán Eloísa, provided outstanding coordination support for the meeting in San Germán. Mr. Aníbal A. Delgado Biaggi, community leader in Valle Hermoso development did the same for the meeting in Hormigueros.

In general, both meetings were characterized by a clear and enthusiastic public support for the total project. All twelve deponents in San Germán and ten in Valle Hermoso development supported the proposed project. No one opposed the project. The main concern expressed by meeting attendants was associated with the time frame for project implementation. Several participants expressed concerns with the ability of the local government to perform required project operation and maintenance. In accordance with these participants, one of the main reasons for frequent flooding along Río Guanajibo is associated with the lack of an adequate maintenance program for the river channel. Following is a general description of the procedure that was followed in the meetings:

The meeting started with welcoming remarks from Lt. Col. Benton and Mr. Dumois. Mrs. Lourdes Rodríguez representing the governor of Puerto Rico and Mrs. Maribel García Palmer representing the Mayor of San Germán expressed their support for the project.

Mr. José Martínez gave a brief introduction explaining the purpose and procedures of the public meeting. Mr. Martínez provided information on the review process for the report and the draft Environmental Impact Statement. Information on the places where the draft report and the EIS could be reviewed was also provided (i.e. municipal government, municipal library, and the library of the University of Puerto Rico, Mayagüez Campus).

The study manager explained to the public in detail the report's recommendations and environmental impacts associated with proposed plan for flood control along Río Guanajibo in the vicinity of San Germán, Hormigueros, and Mayagüez. Funds requirements, Federal and local government responsibilities, cost sharing, and preliminary time frame for project design and construction were also presented.

Following is a summary of the major concerns expressed at the meetings:

- Most of the concerns were related to the construction schedule.

- Debris accumulation in the river channel and mainly in PR Highway 102 bridge about 2 kilometers upstream San Germán were important cause for flood damages in the San Germán area during Hurricane Eloisa in 1975. Consideration should be given by the local government to remove this bridge.

- The lack of maintenance of the existing channel by the pertinent agencies.

- Residents in the El Coto area located downstream proposed channel work in San Germán are concerned by increase in flood stages due to said improvements.

In the case of the Mayagüez-Hormigueros area, the principal comments related to:

- Local drainage problems associated with small streams flowing from the Mayagüez area through PR Highway 2.

- Potential of increase flooding with project levee due to accumulation of runoff along northern section of main levee in the Valle-Hermoso/Buenaventura area.

- Lack of maintenance of the river mouth and too much bureaucracy including U.S. Army Corps of Engineers behind permits to do proper maintenance.

All the comments and questions relating to the recommended plan and its potential adverse or beneficial impact were thoroughly discussed and explained by the study manager, while those relating to operation and maintenance of the existing canal, mouth of the river, and bridges were discussed by the representative from the DNER, while those relating to O&M of local drainage facilities and need for additional improvements were addressed by representatives of the municipal government.

D. Coordination of the Report

Following is a list of letters documenting coordination and support for the project.



DEPARTMENT OF NATURAL AND ENVIRONMENTAL RESOURCES

14 SET 1994

Colonel Terry Rice
District Engineer
U.S. Army Corps of Engineers
Jacksonville District
PO Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Rice:

The Puerto Rico Department of Natural and Environmental Resources has reviewed the Draft Feasibility Report and Environmental Impact Statement for Río Guanajibo, Puerto Rico, and generally concurs with the findings contained therein.

We have participated in the public meetings held on August 23, 1994 in San Germán and Mayaguez to present the study findings to the affected communities and general public. A clear support for the flood protection plans was observed in both meetings.

This letter of intent, while not considered a binding contract, is provided to document our support of the recommended plan of improvements and our intent to act as local sponsor for its implementation. Our Department is legally capable of fulfilling the requirements of local cooperation.

Project funding will be obtained by annual appropriations from the Commonwealth Legislature capital investment program for flood control projects managed by our Department.

Sincerely,

Pedro A. Gelabert
Secretary

ASOCIACION PRO-DAMNIFICADOS HURACAN ELOISA
DE SAN GERMAN, INC.

(TRANSLATION)

August 23, 1994

Department of the Army
Jacksonville District Corps of Engineers
Antilles Office
400 Fernández Juncos Avenue
San Juan, Puerto Rico 00901

Sirs:

We have examined the Río Guanajibo Feasibility Flood Control Study and Environmental Impact Statement for the areas of Mayagüez, Hormigueros, and San Germán. Of the four alternatives studied for the San Germán area, we consider the most viable to be the fourth one, which contemplates the replacement of the bridge at Casto Pérez Avenue and improvements to the canal with a capacity for flood protection for a 10-year event. The implementation of this plan will result in a benefit to cost ratio of \$1.2 for each dollar invested in the project.

We concur with this study and its implementation as recommended by your planning office. We are in the best disposition to offer any additional information you may deem necessary.

Sincerely,

Pablo Martínez
Secretary

Jorge López Zapata
President

Note: Enclosed is a list with the signature of neighbors from our community that concur with the Río Guanajibo Flood Control Project.

We, the undersigned, are residents of San German, Puerto Rico, and concur with the Río Guanajibo Flood Control Study recommended by the U.S. Army Corps of Engineers.

(signatures)

Asociación Pro-Damnificados Huracán Eloísa

DE SAN GERMAN, INC.
 BOX 763
 SAN GERMAN, P. R. ~~00901~~ 00683

23 de agosto de 1994

Department of the Army
 Jacksonville District Corps of Engineers
 Antilles Office
 400 Fernández Juncos Avenue
 San Juan, Puerto Rico 00901-3299

Estimados señores:

Hemos examinado el estudio de viabilidad en el Proyecto Para Control De Inundaciones Declaración De Impacto Ambiental Mayaguez, Hormigueros Y San German Rio Guanajibo. Para el área de San Germán de las cuatro alternativas estudiadas consideramos la más viable la número cuatro que contempla el remplazo del puente en la Avenida Casto Pérez y mejoras al canal con una capacidad para proveer protección para un evento con periodo de recurrencia equivalente a 10 años. La implementación de este plan resultará en una relación de beneficios de \$1.2 por cada dolar invertido en el proyecto.

Endosamos este estudio y su implementación según recomendado por su Oficina de Planificación. Estamos en la mayor disposición de ofrecer información adicional que ustedes estimen sea necesario.

Pablo Martinez
 Pablo Martinez
 Secretario

Cardialmente,

Jorge López Zapata
 Jorge López Zapata
 Presidente

Nota:

Acompañamos firmas de los vecinos de nuestra comunidad que endosan el Proyecto de Control de Inundaciones en el Rio Guanajibo.



Asociación Pro-Damnificados Huracán Eloisa

DE SAN GERMAN, INC.

BOX 763

SAN GERMAN, P. R. 00783-00683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
 endosamos el Proyecto de Control de Inundaciones del Rio Guanajibo
 recomendado por el Cuerpo de Ingenieros del Ejercito de los Estados Unidos

Milagros Guisasa de Lugo

Anilla Seginuela
Aurora Cruz Torres

Alfonso A. Páez
Antonio L. de Páez

Montserrat B. de Martínez
Amable Martínez Sandoval

Jose F. Rodríguez
Pedro G. Cruz B. Cruz
Paulo Rivera Torres

Osvaldo Torres

Norka N. Cruz
Vigencia Velazquez

Roberto R. Nunez
Rosa M. Flores

Lyette del Socorro

San Antonio



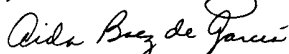
Asociación Pro-Damnificados Huracán Eloisa

DE SAN GERMAN, INC.

BOX 763

SAN GERMAN, P. R. ~~00068~~00683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
 endosamos el Proyecto de Control de Inundaciones del Río Guanajibo
 recomendado por el Cuerpo de Ingenieros del Ejército de los Estados Unidos.

Pedro M. Tómes

Pedro Tacell

Ramona Rodríguez

Don B. Galt

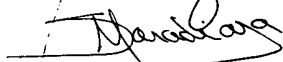
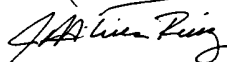
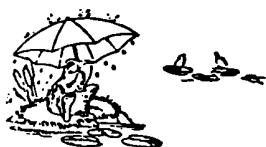
O. Estromitz

Enimilda Acosta

Notario Arroyo Arzobán

Jesús A. Alicia Guzmán

Caudon


Asociación Pro-Damnificados Huracán Eloísa

DE SAN GERMAN, INC.

BOX 763

SAN GERMAN, P. R. 00726-00683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
endosamos el Proyecto de Control de Inundaciones del Río Guanajibo
recomendado por el Cuerpo de Ingenieros del Ejército de los Estados Unidos.

<i>Juan P. Flores</i>	<i>Luis M. Arellano</i>
<i>Luis Tumbado</i>	<i>Jerónimo Santiago</i>
<i>Angel Luis Flores Montalvo</i>	<i>Angel Luis Matos</i>
<i>Juan P. Flores</i>	<i>Israel Rodriguez</i>
<i>Juan P. Flores Vega</i>	<i>Carmona Rodriguez, Inc.</i>
<i>Bernardo Aliso Cruz</i>	<i>Medina Pineda Pineda</i>
<i>Victor A. Quinones Mofas</i>	<i>Miguel A. Lopez</i>
<i>Cesar Feliciano Cruz</i>	<i>Jose E. Lopez</i>
<i>Norman E. Sogano</i>	<i>Jesus Morales Suplido</i>
<i>Mike Oros</i>	<i>Gerardo Juan Figueroa</i>
<i>Orlando Martinez</i>	<i>Andrés Pineda</i>
<i>Orlando Morales</i>	<i>Christy Benjamins</i>
<i>Luis Flores</i>	<i>Jose Pineda</i>
<i>Mike Flores</i>	<i>Manuel Juan de Juan</i>
<i>Monnate Vargas Rodriguez</i>	<i>Gerardo D. Juan</i>
	<i>Jose L. Lome</i>
	<i>Carlos Manuel Lome</i>
	<i>Luis E. Tami Lome</i>
	<i>William L. Lome</i>
	<i>Romero Flores de Ortiz</i>
	<i>Carl Ortiz</i>

Asociación Pro-Damnificados Huracán Eloísa

DE SAN GERMAN, INC.

BOX 763

SAN GERMAN, P. R. ~~XXXXXX~~00683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y endosamos el Proyecto de Control de Inundaciones del Río Guanajibo recomendado por el Cuerpo de Ingenieros del Ejército de los Estados Unidos.

Anna Lee
 Myron E. Brown
 Rosita Diego de Figueroa
 Juan Figueroa Ramirez
 Magaly Figueroa
 Gladys Figueroa
 Angela Torres Alvarez
 Felicidad de Arce
 Myron E. Brown
 Fernando Martinez
 Cynthia Cruz Lopez
 Matilde Barra Rivera
 Francisco Rivera
 Diego Lopez Bonis
 Ben Pablo Lopez
 Ana C. Morales Casel
 Jesus Gregory
 Gabriela Srigany
 Maritza Narisma
~~Natasha~~ Arzamez
 Norman Jr. Arzamez

Asociación Pro-Damnificados Huracán Eloísa

DE SAN GERMAN, INC.

BOX 763

SAN GERMAN, P. R. 00983-00683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
 endosamos el Proyecto de Control de Inundaciones del Río Guanajibo
 recomendado por el Cuerno de Ingenieros del Ejército de los Estados Unidos

Rafy Pagan Del Toro

Noemi Del Toro

Alberto Pagan

Lurdes Camacho

Victoria Seda

Maria Isabel Rabier

Eugenio Ruiz Valle

Jirna Ruiz Valle

Carlos D. Ruiz Valle

Elba Loreto de Vazquez

Calisto Gonzales

Maria A. Martinez

Carmen D. Munoz

Victor D. Quinones

Shirley L. Quinones

Victor D. Quinones Jr.

Ruben D. Quinones

Rafael D. Quinones

Wylma Munoz de Montalvo

Gustavo L. Montalvo

Felix C. Montalvo Junior

Edgardo Montalvo Junior

ESTHER Munoz de Montalvo, ms.

D-9 D



Asociación Pro-Damnificados Huracán Eloísa
DE SAN GERMAN, INC.
 BOX 763
 SAN GERMAN, P. R. 00983-0063

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
 endosamos el Proyecto de Control de Inundaciones del Río Guanajibo
 recomendado por el Grupo de Ingenieros del Ejercito de los Estados Unidos.

C's con G. J. Santos
Paul Luvati
Guerra Luvati No somos de la asociación, pero respaldamos el proyecto
Gil Soto
Alfonso Luvati
Pedro Guerra
Diana N. Alvarez
Juan Luvati
Alfonso C. Díaz
Carlos Miguel Alvarez
Samuel Estévez c.p. Luvati
Juan J. Navarro



Asociación Pro-Damnificados Huracán Eloisa

DE SAN GERMAN, INC.

BOX 763

SAN GERMAN, P. R. 00983-0683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
 endosamos el Proyecto de Control de Inundaciones del Río Guanajibo
 recomendado por el Cuerpo de Ingenieros del Ejército de los Estados Unidos.

Donat Juan Ruiz
 Rafael B. arcu
 Nelson A. Padilla
 Karolita Gutierrez
 Fernando Ocasio Beltrán
 Juan C. de Ocasio
 H. H. H. H. H.
 J. Caballero
 Diana Cardona
 Luis A. Caballero
 Eusebio Perez
 Raul Perez
 Nilsa Buille
 Luis Lizaso
 Luis Lizaso Buille
 Juan C. Gutierrez
 David Santiago



Virginia Salcedo
 Wilma Balie
 Enrique Amable
 Arsenio Ayala
 Mrs. Ayala
 Jaime Rivera Flores
 Wilson Rodriguez Tori
 Juan Ramirez
 Jorge Cardona
 Gloria J. Gutierrez
 Roberto Amador
 Lina Gutierrez
 Lorena Gutierrez

Asociación Pro-Damnificados Huracán Eloisa

DE SAN GERMAN, INC.

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SAN GERMAN, P. R. 00863-00683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
 endosamos el Proyecto de Control de Inundaciones del Río Guanajibo
 recomendado por el Cuerno de Ingenieros del Ejercito de los Estados Unidos.

- 1- Domingo Vega
- 2- Rafaela Suman
- 3- Emma Castina
- 4- Leticia Mading Vega
- 5- Magaly Cruz Marti
- 6- Roberto Sepúlveda
- 7- Teresa Marti Vega
- 8- Amparo Pérez
- 9- Nelson Berio
- 10- Ana C. de Pinero
- 11- Rogelio Pinero
- 12- Araceli de la Cruz
- 13- Lydia Pérez de la Cruz
- 14- Araceli de la Cruz
- 15- Juana Rana
- 16- Rebecca Lugo



Asociación Pro-Damnificados Huracán Eloísa
DE SAN GERMAN, INC.
 BOX 763
 SAN GERMAN, P. R. 00723-00683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
 endosamos el Proyecto de Control de Inundaciones del Río Guannjibo
 recomendado por el Cuerpo de Ingenieros del Ejército de los Estados Unidos.

- | | |
|---------------------------|----------------------|
| 1- Madelin Padilla | 18. Francisco Quirón |
| 2- María Hernandez | 19. Carmen Ortiz |
| 3- Miguel Lamborg | 20. Aida Figueroa |
| 4- Guiche Hernandez | 21- Rafael Flores |
| 5- Vidalia Aponte Llanos | 22- Jesus Santana |
| 6- Jamid Ruiz | 23- Emilio Toro |
| 7. Judy Ruiz | |
| 8. Joni A. Ruiz | |
| 9. Joannette Ruiz | |
| 10. Joni A. Ruiz Aponte | |
| 11 - Primitivo Justiniano | |
| 12 Laida - Justiniano | |
| 13 Eduardo Dattel | |
| 14 Otilio Pagan | |
| 15 - Consuelo Bonnet | |
| 16. Rosita Quintones | |
| 17. Julio Rivera | |

Asociación Pro-Damnificados Huracán Eloísa

DE SAN GERMAN, INC.

BOX 763

SAN GERMAN, P. R. 00986-00683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
endosamos el Proyecto de Control de Inundaciones del Río Guanajibo
recomendado por el Cuerpo de Ingenieros del Ejército de los Estados Unidos.

- 18 - *Vito Nazario*
- 19 - *Carmen M. Velez*
- 20 - *Paul Santos Jutier*
- 21 - *Carmen P. Jutier*
- 22 - *Manuel Bailla*
- 23 - *Juan Bailla*
- 24 - *Manuel Ponce*
- 25 - *Fernando A. Ponce*
- 26 -



Asociación Pro-Damnificados Huracán Eloísa

DE SAN GERMAN, INC.

BOX 763

SAN GERMAN, P. R. ~~00983~~ 00683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
 endosamos el Proyecto de Control de Inundaciones del Río Guanajibo
 recomendado por el Cuerpo de Ingenieros del Ejército de los Estados Unidos.

- 1- William Moreno Santiago
- 2- Laura C. Moreno
- 3- J. H. L. S. L.
- 4- Alfredo Ortiz
- 5- Elvira Roldán
- 6- Fátima C. M. Chantón
- 7- Georgina Santana
- 8- Cándido Rodríguez
- 9- Luisa H. Pérez Vafonten
- 10- Mónica Roldán Rodríguez
- 11- Ana Moreno
- 12- Elvira Vito Santiago
- 13- Ramona H. Rodríguez
- 14- Rosa Rodríguez
- 15- Salvadora Segura
- 16- María Moreno
- 17- Orlando Moreno



Asociación Pro-Damnificados Huracán Eloisa

DE SAN GERMAN, INC.

BOX 763

SAN GERMAN, P. R. 00986-00683

Los abajo firmantes somos residentes de San Germán, Puerto Rico y
endosamos el Proyecto de Control de Inundaciones del Río Guanajibo
recomendado por el Cuerno de Ingenieros del Ejercito de los Estados Unidos.

Gloria D. M. Santiago La Marta. CES
Carmen J. Santiago Santiago San Germán
Amalia Juvenal Santiago "
Juliana C. Santiago Santiago
Maria L. Torres
Paula Santiago Sosa
Carmen J. Santiago



RIO GUANAJIBO DRAFT FEASIBILITY REPORT

MAILING LIST
LIST OF AGENCIES/ENTITIES TO WHOM REPORTS WERE MAILED FROM CESAJ-DS-PD
July 1994

COMMONWEALTH OFFICIALS

Hon. Pedro Rosselló González
Governor of Puerto Rico
La Fortaleza
Box 82
San Juan, Puerto Rico 00901

Hon. Pedro Gelabert
Secretary of Natural &
Environmental Resources
P. O. Box 5887, Puerta de Tierra
San Juan, Puerto Rico 00906
Tel. 723-2055

Eng. Julio F. Dumois
Assistant Secretary
Flood Control Area
Department of Natural &
Environmental Resources
P. O. Box 5887, Puerta de Tierra
San Juan, Puerto Rico 00906
Tel. 725-3852

Mr. José González Liboy
Director, Coastal Zone Management
Department of Natural &
Environmental Resources
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San Juan, Puerto Rico 00906
Tel. 724-5516

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Executive Director
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Santurce, Puerto Rico 00916
Tel. 756-2452

Mrs. Norma E. Burgos Andújar
Chairwoman, Puerto Rico Planning Board
P. O. Box 41119, Minillas Station
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Tel. 727-4444

Mr. Héctor Russé Martínez
President
Environmental Quality Board
Box 11488
Santurce, Puerto Rico 00910
Tel. 767-8181

Hon. Neftalí Soto Santiago
Secretary of Agriculture
P. O. Box 10163
Santurce, Puerto Rico 00908
Tel. 721-2120

Mr. Jorge E. Aponte
Director, Office of Budget
and Management
Box 3228
San Juan, Puerto Rico 00902
Tel. 725-7019

Mr. Epifanio Jiménez Meléndez
Director, Civil Defense
Box 5127, Puerta de Tierra Station
San Juan, Puerto Rico 00906
Tel. 725-3234

Eng. César A. Barreto Bosques
Administrator
Permits and Regulations Administration
P. O. Box 41179, Minillas Station
Santurce, Puerto Rico 00940
Tel. 723-0380

Hon. Carlos Romero Barceló
Resident Commissioner of Puerto Rico
U. S. House of Representatives
427 Cannon Building
Washington, DC 20515
(202) 225-2615

Mr. Juan F. Woodroffe, President
P. R. Industrial Development Company
G. P. O. Box 2350
San Juan, Puerto Rico 00936
Tel. 764-1175

Hon. Carlos I. Pesquera Morales
Secretary of Transportation and
Public Works
P. O. Box 41269, Minillas Station
Santurce, Puerto Rico 00940
Tel. 723-1390

Dr. Arleen Pabón
State Historic Preservation Officer
Office of the Governor
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Box 82
San Juan, Puerto Rico 00901
Tel. 721-3737

Mr. José Antonio Alicea
Aide to the Governor
for Infrastructure
La Fortaleza
Box 82
San Juan, Puerto Rico 00901
Tel. 721-6292

Eng. Miguel A. Cordero
Executive Director
Puerto Rico Electric Power Authority
G. P. O. Box 4267
San Juan, Puerto Rico 00936-4267
Tel. 725-4232

Executive Director
Puerto Rico Telephone Co
GPO Box 998
San Juan PR 00936

Executive Director
PR Land Authority
PO Box 9745
Santurce PR 00908

Executive Director
Public Buildings Authority
Box 41029
Santurce PR 00940

Director, Center for
Investigations
Institute of Puerto Rican
Culture
Box 4184
San Juan PR 00905

LOCAL OFFICIALS

Hon. Melanio Bobé Acevedo
Mayor of Hormigueros
Box 97
Hormigueros, Puerto Rico 00680

Hon. Jorge A. Ramos Comas
Mayor of San Germán
Box 85
San Germán, Puerto Rico 00683

Hon. José Guillermo Rodríguez
Mayor of Mayagüez
Box 447
Mayagüez, Puerto Rico 00681

OTHERS

University of Puerto Rico
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P. O. Box 5000, College Station
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Public Library
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Public Library
Municipality of Hormigueros
Box 97
Hormigueros, Puerto Rico 00660

Public Library
Municipality of San Germán
11 José Julián Acosta Street
San Germán, Puerto Rico 00683

RIO GUANAJIBO DRAFT FEASIBILITY REPORT

MAILING LIST

LIST OF AGENCIES/ENTITIES TO WHOM REPORTS WERE MAILED TO FROM CESAJ-PD-ES
July 1994

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Caribbean Island Office
U. S. Fish and Wildlife Service
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Director
Department of Commerce
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Environmental Impact
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Washington, DC 20005-4013

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Washington, DC 20024-2610

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Washington, DC 20024-2514

Executive Director
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Washington, DC 20004-2590

Mr. James Pulliam
Regional Director
U. S. Fish and Wildlife Service
1875 Century Boulevard
Atlanta, GA 30345

Letters of Coordination

T R A N S L A T I O N
of Environmental Quality Board Letter

September 19, 1994

Mr. A.J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Subject: JCA 94-0006 (ARMY)
Flood Control Project
Río Guanajibo
Mayagüez, Hormigueros, San Germán

Dear Mr. Salem:

The Puerto Rico Environmental Quality Board has reviewed the Draft Environmental Impact Statement (DEIS) submitted for the referenced project.

We understand that with it your agency has complied with the requirements of Article 4(c) of the Law of Environmental Public Policy (Law number 9 of 18 June 1990) as amended. Therefore, this Board has determined to accept the aforesaid document as the Final Environmental Impact Statement (FEIS). Nonetheless, in order to fully comply with the regulation on Environmental Impact Statements of this Board, your agency must comply with the following recommendations:

1. Utilize all necessary noise control measures during construction phase of the project in order to assure tranquility and general well-being of the adjacent areas. Construction activities should be undertaken during day time.
2. Prior to commencement of construction or any movement of lands in the area, should secure from this Board the following permits:
 - a) Permit for Source of Emission (PFE) of fugitive dusts
 - b) Permit for activity generating solid waste (Form DS-3)
 - c) Permit for Plan for Control of Erosion and Sediment of Soils (CEST)
3. During construction, it is important to implement measures to control emissions of fugitive dusts in accordance with rules 404 and 108 of the current Regulation for the Control of Air Pollution (RCCA). These measures should be implemented while undertaking tasks that involve site preparation, removal of top soil, movement and leveling of terrain, and vehicles traffic by areas of access and roads.

4. Prior to commencing proposed project, should submit to the Air Quality Control Bureau of this Board, Authorization for Construction of Project in accordance with rules 203 of the RCCA.
5. During construction, should implement the necessary measures to avoid pollutants such as oil, solvents, grease or other chemical products be carried by runoff into bodies of water or the water sewer systems.
6. If the project involves any water discharge from the construction activities into a body of water, you should consult the Federal Environmental Protection Agency to determine if an "NPDES" permit is needed.
7. Coordinate with the Puerto Rico Department of Natural Resources and the U.S. Fish and Wildlife Service the alternatives for disposal of dredge materials and any borrow areas.
8. The U.S. Army Corps of Engineers should coordinate with the proper agencies project's impacts to cultural and historical resources, and utilities such as water and sewer lines, power and telephone lines and bridges.
9. Request the corresponding Water Quality Certificate from this Board.
10. Regarding determination by this Board to accept the draft EIS as the final EIS, the Public Notice enclosed with this letter should be published in a newspaper of general circulation in Puerto Rico in accordance with Section 5.5.6.2 of the Regulation on Environmental Impact Statements. Please provide this Board with a copy of the newspaper's payment voucher for the Public Notice as established in Section 5.5.2.2 of the aforesaid Regulation. The construction of the proposed project should not be initiated until a period of at least 30 days, elapsed from the date of the Public Notice or notification of the final EIS.

Thank you very much for your cooperation in maintaining and preserving the quality of our environment.

Cordially,

Héctor Russé Martínez
President

Enclosure: We are including copy of the Environmental Notice



United States Department of the Interior

FISH AND WILDLIFE SERVICE
Caribbean Field Office
P.O. Box 481
Boqueron, Puerto Rico 00622



September 19, 1994

Mr. A. J. Salem
Chief, Planning Division
US Army Corps of Engineers
PO Box 4970
Jacksonville, Florida 32232

Re: Guanajibo Flood Control

Dear Mr. Salem:

This is in regards to the recent modifications that have occurred with the Guanajibo Flood Control Project. These modifications include the elimination of the Caño Majagual portion of the project and additional flood protection for an existing radio station. This additional protection would entail the isolation of 6 acres of mangroves between the levee and an existing subdivision.

The isolated mangroves would either convert slowly to freshwater wetlands as salinity decreases, or more likely will be subject to development since the area will be protected from flooding.

We recommend that the Corps seek to minimize to the maximum extent possible the isolation of these mangroves. Alternatives such as extending the flood wall around the radio station, or realignment of the levee closer to the subdivision should be discussed in the Final EIS.

Since the Majagual portion has been eliminated we agree with the Corp's determination of a 1:1 mitigation ratio with planting. We look forward to continued coordination during the design phase of the mitigation plan. If you have any questions please call Felix Lopez of my staff.

Sincerely,

James P. Oland
James P. Oland
Field Supervisor

fhl
cc:
DNR, San Juan
COE, San Juan
ARD, FWS, Atlanta

OPTIONAL FORM NO. (7-89)

FAX TRANSMITTAL		# of pages = 1
To: Roberto Cotes	From: Felix Lopez	
Dist. Agency: Planning	Phone: 1	
Fax: Uperat	Fax: 2	

FORM 7500 4/83 377-7386 2000-101 GENERAL SERVICES ADMINISTRATION

July 6, 1994

Planning Division
Environmental Branch

TO ADDRESSEES ON ENCLOSED LIST:

Enclosed is a copy of the Revised Draft Feasibility Report and Draft Environmental Impact Statement for the Rio Guanajibo Flood Control Study, for your review and comment. The Draft EIS is printed on blue pages and bound within the Main Report. In order to be considered, your comments should be submitted within 45 calendar days to the above address.

Sincerely,

A. J. Salem
Chief, Planning Division

Enclosure

267

July 1, 1994

Planning Division
Environmental Branch

Director
Office of Environmental Review (A-104)
Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

Dear Sir:

Enclosed are five copies of the Revised Draft Feasibility Report and Draft Environmental Impact Statement for the flood control study of the Rio Guanajibo at Mayaguez and San Germán, Puerto Rico, for publication of a notice of availability in the Federal Register.

Sincerely,

A. J. Salem
Chief, Planning Division

Enclosures

The US Department of Transportation's Federal Highway Administration (FHWA) has adopted the US General Services Administration's final EIS filed with the US Environmental Protection Agency on 8-9-93. The FHWA was a Cooperating Agency for the above final EIS. Recirculation of the document is not necessary Under § 1506.3(c) of the Council on Environmental Quality Regulations.

EIS No. 940272, Draft EIS, COE, PR, Rio Guanajibo River Basin Flood Protection Project, Implementation and NPDES Permit, Mayaguez and San German, PR, Due: August 29, 1994, Contact: William J. Fonferek (904) 232-2803.

EIS No. 940273, Draft EIS, FEM, CA, Oakland City Administration Building Project, Construction, Funding and Permit Approval, for Replacement of City Hall in the City Hall Plaza, Oakland, CA, Due: August 29, 1994, Contact: Sandro Amaglio (415) 923-7284.

EIS No. 940274, Final EIS, FAA, MN, Minneapolis-St. Paul International Airport, Runway 4-22 Extension, Funding, Wold-Chamberlain Field, Hennepin County, MN, Due: August 15, 1994, Contact: Glenn Orcutt (612) 725-4221.

Amended Notices

EIS No. 940250, Draft EIS, DOE, NAT, Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs, Implementation, Due: September 30, 1994, Contact: Tom Wichmann (800) 682-5583.

Published FR 07-01-94 Title Change and Contact Person and Telephone Number Change.

Dated: July 12, 1994.

Richard E. Sanderson,

Director, Office of Federal Activities.

[FR Doc. 94-17285 Filed 7-14-94; 8:45 am]

BILLING CODE 6560-60-J

[OPPTS-69983; FRL-4900-8]

Certain Chemicals; Premanufacture Notices

AGENCY: Environmental Protection Agency (EPA).
ACTION: Notice.

SUMMARY: Section 5(a)(1) of the Toxic Substances Control Act (TSCA) requires any person who intends to manufacture or import a new chemical substance to submit a premanufacture notice (PMN) to EPA at least 90 days before

manufacture or import commences. Statutory requirements for section 5(a)(1) premanufacture notices are discussed in the final rule published in the Federal Register of May 13, 1983 (48 FR 21722). In the Federal Register of November 11, 1984, (49 FR 46066) (40 CFR 723.250), EPA published a rule which granted a limited exemption from certain PMN requirements for certain types of polymers. Notices for such polymers are reviewed by EPA within 21 days of receipt. This notice announces receipt of 4 such PMN(s) and provides a summary of each.

DATES: Close of review periods:

Y 94-118, June 28, 1994.

Y 94-119, 94-120, June 29, 1994.

Y 94-121, July 10, 1994.

FOR FURTHER INFORMATION CONTACT: Susan B. Hazen, Director, Environmental Assistance Division (4708), Office of Pollution Prevention and Toxics, Environmental Protection Agency, Rm. E-545, 401 M St., SW., Washington, DC, 20460 (202) 554-1404, TDD (202) 554-0551.

SUPPLEMENTARY INFORMATION: The following notice contains information extracted from the nonconfidential version of the submission provided by the manufacturer on the PMNs received by EPA. The complete nonconfidential document is available in the TSCA Nonconfidential Information Center (NCIC), NE-B607 at the above address between 12 noon and 4 p.m., Monday through Friday, excluding legal holidays.

Y 94-118

Manufacturer: Confidential.
Chemical: (G) Acrylic terpolymer.
Use/Production: (S) Additive for industrial coatings to improve surface appearance. Prod. range: Confidential.

Y 94-119

Manufacturer: Confidential.
Chemical: (G) Polyurethane.
Use/Production: (G) Additive for magnetic tapes. Prod. range: Confidential.

Y 94-120

Manufacturer: Seydel Companies.
Chemical: (G) Acid terminated terephthalate/isophthalate polyesther resin.
Use/Production: (S) Textile sizing other processes, adhesives. Prod. range: Confidential.

Y 94-121

Manufacturer: Reichhold Chemicals, Inc.
Chemical: (G) Polyester resin.
Use/Production: (S) Mine bolt resin. Prod. range: Confidential.

List of Subjects

Environmental protection.
Premanufacture notification.

Dated: July 6, 1994.

Frank V. Caesar,

Acting Director, Information Management Division, Office of Pollution Prevention and Toxics.

[FR Doc. 94-17291 Filed 7-14-94; 8:45 am]

BILLING CODE 6560-60-F

[OPPTS-69983; FRL-4900-8]

Certain Chemicals; Premanufacture Notices

AGENCY: Environmental Protection Agency (EPA).
ACTION: Notice.

SUMMARY: Section 5(a)(1) of the Toxic Substances Control Act (TSCA) requires any person who intends to manufacture or import a new chemical substance to submit a premanufacture notice (PMN) to EPA at least 90 days before manufacture or import commences. Statutory requirements for section 5(a)(1) premanufacture notices are discussed in the final rule published in the Federal Register of May 13, 1983 (48 FR 21722). In the Federal Register of November 11, 1984, (49 FR 46066) (40 CFR 723.250), EPA published a rule which granted a limited exemption from certain PMN requirements for certain types of polymers. Notices for such polymers are reviewed by EPA within 21 days of receipt. This notice announces receipt of 10 such PMN(s) and provides a summary of each.

DATES: Close of review periods:

Y 94-108, May 29, 1994.

Y 94-109, May 30, 1994.

Y 94-110, 94-111, 94-112, June 2, 1994.

Y 94-113, 94-114, June 6, 1994.

Y 94-115, 94-116, June 20, 1994.

Y 94-117, June 21, 1994.

FOR FURTHER INFORMATION CONTACT: Susan B. Hazen, Director, Environmental Assistance Division (TS-799), Office of Pollution Prevention and Toxics, Environmental Protection Agency, Rm. E-545, 401 M St., SW., Washington, DC, 20460 (202) 554-1404, TDD (202) 554-0551.

SUPPLEMENTARY INFORMATION: The following notice contains information extracted from the nonconfidential version of the submission provided by the manufacturer on the PMNs received by EPA. The complete nonconfidential document is available in the TSCA Nonconfidential Information Center (NCIC), NE-B607 at the above address between 12 noon and 4 p.m., Monday



DEPARTMENT OF NATURAL AND ENVIRONMENTAL RESOURCES

September 6, 1994

Mr. José A. Martínez
Chief, Planning Section
U.S. Army Corps of Engineers
400 Fernández Juncos Ave.
San Juan, P.R. 00901-3299

Dear Mr. Martínez:

This is in reference to land requirements for a disposal site associated with proposed channel improvements for Río Guanajibo at San Germán.

There are about 300,000 c.y. of material to be excavated from Río Guanajibo in the vicinity of San Germán. In accordance with available geotechnical information, the material to be excavated is suitable for construction purposes. Therefore, it is recommended that the excavated material be deposited at a temporary disposal area to provide for local demand subject to the Department's needs at the time of construction of this project.

Real estate requirements should then be based on a temporary use of the disposal site.

Sincerely,

Julio F. Dumois
Julio F. Dumois
Assistant Administrator for
Mineral and Hydrological
Resources Area

JAA/LH/



Medina Governmental Center, North Wing,
 De Diego Ave., Room 22
 P. O. Box 41116, San Juan, P. R. 00940-1116

August 24, 1994

A. J. Salen, Chief
 Planning Division
 Department of the Army
 Jacksonville District
 Corps of Engineers
 P.O. Box 4970
 Jacksonville, Florida 32232-0019

Dear Mr. Salen:

This is in reference to your request for comments on the draft Feasibility Report and Environmental Impact Statement (DEIS) for the Rio Guanajibo Flood Control Project in the vicinity of the Mayaguez-Hormigueros and San Germán areas.

According to the report, the flood control measures were evaluated separately for the Mayaguez-Hormigueros and the San Germán areas for purpose of optimization of net National Economic Development benefits. The recommended flood control plan for the Mayaguez-Hormigueros area includes several structural elements for the protection against the 100 year-flood to developed areas of Guanajibo Home, San José, Ramirez de Arellano, Valle Hermoso, Buenaventura and San Rosalido. The plan provides for a 96 percent reduction of the potential urban flood damages and will protect about 2,234 families. The plan also minimizes the potential environmental impact in the area. The plan is in compliance with the Land Use Plans of both municipalities.

On the other hand, for San Germán area the recommended plan consists of channel improvements and replacement of bridge at PR Highway 119 to provide protection against the 10 year flood. Other plans were evaluated for the urban protection against the 100 year-flood and 25 year-flood, however the plan that provides the better benefit-cost ratio of 1.2/1.0 was the 10 year flood plan. The recommended plan will protect about 292 families. The channel improvements design storm will be equal to the level of protection which means that the properties to be protected by the project are still subject to floodplain regulations and flood insurance requirements. We recommend that, in addition to the 10 year-storm design, take into consideration the 100 year flood levels in the design phase of the project in order to increase the level of protection and minimize the 100 year flood impact on adjacent properties.

Cordially,


 Horacio E. Burgos-Andájar
 Chairman

BA/RM/cha

RIO GUANAJIBO FEASIBILITY REPORT

Appendix E
Economic Analysis

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Appendix E
Economic Analysis

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RIO GUANAJIBO FEASIBILITY REPORT

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I. INTRODUCTION

This appendix presents a description of the detailed study area's estimated potential flood damage for existing and future conditions as well as the benefits to be derived from the implementation of alternative flood control plans for these areas.

II. FLOOD DAMAGE ESTIMATES

A. General

This section comprises a description of damage reaches and zones of the property subject to flooding, values of property, and depth-damage relationships used to calculate flood damage estimates. Historical, potential flood damages, and residual damage estimates for the alternative flood control plans under consideration are also included.

The social and economic conditions pertaining to the Municipalities of Mayagüez-Hormigueros and San Germán are provided in the Main Report. Inventory of property subject to flooding was conducted through field visits using flood maps for existing conditions developed as part of this study.

B. Detailed Study Areas and Damage Reaches

For purpose of damage estimates analysis, plan formulation and evaluation, the study area is divided into two areas: the Mayagüez-Hormigueros area, which extends from the coast to the vicinity of Highway 100, and the area in the vicinity of San Germán between Highways 360 and 119. This was done because each of these areas represent a separable typographic, hydraulic, and socioeconomic entity. The Mayagüez-Hormigueros area is further subdivided into six reaches, while the San Germán area is subdivided into eleven reaches.

Plates E-1A and E-1B show the delineation of the reaches for the Mayagüez-Hormigueros area, while Plate E-2 shows similar information for the San Germán area. Table E-1 lists the various reaches for each area.

C. Inventory of Property Subject to Flooding

In this report, property subject to flooding is grouped into six land use categories. These are: residential; commercial; public; nonprofit organization facilities use; utilities, highways, and streets. The following paragraphs describe the various land uses and the property subject to flooding:

1. Residential. In the Mayagüez-Hormigueros area a total of 2,234 residential structures are flooded by the 100-year flood. These structures are distributed among 10 different housing developments all of which are part of the Mayagüez Metropolitan Area.

In the San Germán area, 502 family-housing structures are subject to flooding by the 100-year flood.

TABLE E-1
RIO GUANAJIBO FEASIBILITY REPORT

IDENTIFICATION OF REACHES FOR EACH STUDY AREA

MAYAGUEZ-HORMIGUEROS AREA

REACH	DEVELOPMENT-LOCATION
1	Guanajibo Homes to Highway 102--Sea shore to cross section 38
2	San José Development to Highway 102--Sea shore to cross section 38 Ramírez de Arrellano and baseball park to Highway 102 --Sea shore up to cross section 38 Vista Verde Development to Highway 2--Cross section 38 to 37
3	Parcelas Castillo to Highway 114--Cross section 37 to 36 Guanajibo Gardens--Cross section 36 to bridge on Río Hondo (besides Industrial Park)
4	Buenaventura Development to bridge on Río Hondo up to Highway 114 Valle Hermoso Development, Highway 343 up to Highway 100,
5	San Romualdo Rural Community, Highway 100 (XS 30) up to cross section 28
6	Residential Structures along Highway 345 up to cross section 28

SAN GERMAN AREA

REACH	DEVELOPMENT-LOCATION
1	Residential structures along Highway 347--Cross section 18 to cross section 17 west bank
2	North Bank, Highway 360
3	PRASA--along Highway 360--Cross section 18 to 17 east bank
4	PREPA--along Highway 360--Cross section 17 to 16
5	Residential along cross section 16 to bridge on Highway 360 north bank (Public Works)
6	Industrial zone north bank Highway 362 up to cross section 15
7	Baseball park on Highway 360
8	Vivoni Housing Development and other housing structures on Highway 360 to Highway 119 south bank
9	Santa Marta Development and Riverside Highway 119 to cross section 13 south bank
10	North bank east of Highway 119
11	West bank of river

Table E-2 shows for each of the study areas and for selected flood frequencies the number of residential structures affected in each of the reaches.

All of the residential sectors affected by flooding consist of reinforced concrete units, except for some scattered units constructed of mixed concrete-wood frame. Over 95 percent of the housing developments are detached single-family housing. In the Mayagüez area there are 160 units of duplex housing and 6 walk-up building apartments. In the San Germán area all residential structures are single-detached units. About 75 percent of the families affected belong to middle income groups.

Each housing development is generally homogeneous with basically the same design utilized for building each house. Each house is a 3 bedrooms/two bathroom house with living and dining room, kitchen, and carport for 1 or 2 cars. Size of the lot varies from 350 to 450 square meters.

2. Commercial. A total of 52 commercial establishments in the Mayagüez-Hormigueros study area are affected by the 100-year flood. In the San Germán area there are 47 such commercial outlets. These establishments are grouped in different categories according to the type of business activity, the merchandise or services offered, and the similarities in the display of contents. The various commercial categories utilized for grouping the commercial establishments for purpose of flood damage are as follows:

Commercial category 1. Professional services offices, general merchandise outlets, miscellaneous retail stores, auto parts stores, sporting goods stores, drug stores, electrical equipment stores, food stores, auto services outlets, and apparel and accessories stores.

Commercial category 2. Personal and business services outlets.

Commercial category 3. Eating and drinking places, repair services outlets, and small building materials outlets.

Commercial category 4. Auto dealer outlets.

Commercial category 5. Large lumber and building materials distributors.

Commercial category 6. Finance institutions and real estate offices.

Commercial category 8. Shopping centers.

Most of the business outlets affected by floods in the Mayagüez-Hormigueros area as well as in the San Germán area are small sized community or neighborhood-oriented businesses serving the local population.

Table E-3 shows the distribution of commercial establishments affected by flood in each area by major commercial category and their associated average structure and contents values.

TABLE E-2
RIO GUANAJIBO FEASIBILITY REPORT
INVENTORY OF PROPERTY SUBJECT TO FLOODING
RESIDENTIAL LAND USE

MAYAGUEZ-HORNIGUEROS STUDY AREA		NUMBER OF STRUCTURES			
REACH	DEVELOPMENT	2-YEAR	10-YEAR	25-YEAR	100-YEAR
1	Guanajibo Homes (Along Highway 102)	19	272	272	272
2	San José Development (Highway 102) Ramírez de Arrellano (Highway 102) Vista Verde Development (Highway 2)	0	271	576	703
3	Parcelas Castillo (Highway 114) Guanajibo Gardens (Besides Industrial Park)	7	10	20	44
4	Buena Ventura Dev. (Highway 114) Valle Hermoso Development	229	891	1,071	1,153
5	San Romualdo Rural Comm.	14	36	42	54
6	Residential Structures along Highway 345	8	8	8	8
	TOTAL	277	1,488	1,989	2,234
SAN GERMAN STUDY AREA		NUMBER OF STRUCTURES			
REACH	DEVELOPMENT	2-YEAR	10-YEAR	25-YEAR	100-YEAR
1	Res. Along Highway 347	4	52	70	90
2	Res. Along North Bank (Highway 360 - Highway 119)	0	0	13	18
5	Res. Along Cross Sect. 16 to Bridge on Highway 360	0	0	0	20
8	Vivoni & Other Developments	0	10	29	29
9	Santa María & Riverside Developments	0	200	265	303
10	North Bank-East of Highway 119 Sector	0	0	1	2
11	West Bank Sector	4	30	30	40
	TOTAL	8	292	408	502

*Only reaches with residential development.

TABLE E-3
 RIO GUANAJIBO FEASIBILITY REPORT
 DISTRIBUTION OF COMMERCIAL OUTLETS BY AREA, MAJOR COMMERCIAL CATEGORY
 AND THEIR ASSOCIATED TOTAL STRUCTURE AND CONTENT VALUE

MAYAGUEZ - HORMIGUEROS AREA				
	COMMERCIAL CATEGORY	NUMBER OF STRUCTURES	STRUCTURE VALUE	CONTENT VALUE
1	Professional services, general merchandise, apparel and accessory stores, etc.	27	\$2,546,350	\$3,525,260
2	Personal and business services	3	280,000	645,420
3	Eating, drinking, outlets	16	1,874,100	635,160
4	Auto dealers outlets	4	448,000	307,200
8	Neighborhood shopping center	4	292,000	2,116,320
SAN GERMAN AREA				
	COMMERCIAL CATEGORY	NUMBER OF STRUCTURES	STRUCTURE VALUE	CONTENT VALUE
1	Professional services, general merchandise, apparel and accessory stores, etc.	32	\$3,103,500	\$1,443,700
2	Personal and business services	2	168,000	354,000
3	Eating, drinking, outlets	8	771,750	2,336,700
6	Finance institutions, real estate business	2	41,250	82,500
8	Shopping center	3	1,362,000	2,960,000

3. Public. The public category comprises all facilities operated by the Commonwealth and municipal governments. In the Mayagüez-Hormigueros area it includes schools, a public health center, a National Guard Armory, and a Police Department regional office. Also included in this category is the Isidoro García Baseball Stadium, which is a regional facility. Similar facilities are also located in San Germán.

4. Nonprofit organizations. In the Mayagüez-Hormigueros area this category groups one private school, 6 churches, 1 center for the elderly, 1 political party office, and 2 private clubs facilities.

5. Utilities. Included in this category for the Mayagüez-Hormigueros area are: a warehouse and a utility structure of the Puerto Rico Electric Power Authority (PREPA), and a treatment plant of the Puerto Rico Aqueducts and Sewers Authority (PRASA).

This category also includes the water, telephone, sewage, and electric power lines and meters within the flood plain. No detailed data are available on the number of such facilities; therefore, they are measured on the basis of acreage of land developed.

6. Highways and streets. This category includes all sidewalks, roads, highways, and streets in the flood plain area. Kilometers of affected streets and highways by flooding were measured from flooded area maps developed for this study. Approximately 53 kilometers are affected by the 100-year event in the Mayagüez-Hormigueros area.

Table E-4 summarizes for each detailed study area and by land use category the number of structures flooded by the 25- and the 100-year floods.

D. Assessment of Property Values

Values of structures and contents for all types of facilities within the flood plain are estimated on the basis of field visits, revision of appraisals records in the area, construction cost data from the Puerto Rico Permits and Regulations Administration, and comparable data from recent completed survey reports such as the Río de la Plata Limited Reevaluation Report (Jacksonville District, 1992) and the Río Grande de Arecibo Survey Report (Jacksonville District, 1993). Values reflect 1994 price level replacement costs and do not include land values.

1. Residential. Residential contents values were determined through field visits and from comparable data collected for the survey reports mentioned above. For these studies detailed information on the value of contents was collected for all residential developments in the study area, and an average value of contents was estimated for each one of them. Homogeneity of design of structures and income group families in each development allowed for the use of average figures to estimate total structure and content values.

Table E-5 shows for each of the study areas average structure and content values per unit for each residential development in each of the detailed study areas.

TABLE E-4

RIO GUANAJIBO FEASIBILITY REPORT

DISTRIBUTION OF STRUCTURES AFFECTED BY SELECTED FLOOD FREQUENCY
AND PRINCIPAL LAND USE CATEGORY
FOR EACH OF THE STUDY AREAS

MAYAGUEZ AND HORMIGUEROS AREA		
LAND USE	25-YEAR	100-YEAR
Residential	1,989	2,234
Commercial	40	54
Public	14	14
Non-Profit	11	11
Utilities	10	10
Total	2,064	2,321
SAN GERMAN AREA		
Residential	408	502
Commercial	15	47
Public	12	20
Non-profit	12	2
Utilities	7	7
Total	444	578

TABLE E-5
RIO GUANAJIBO FEASIBILITY REPORT

AVERAGE STRUCTURE AND CONTENT VALUES
RESIDENTIAL LAND USE

REACH	SECTOR	PER UNIT AVERAGE STRUCTURE VALUE	PER UNIT AVERAGE CONTENTS VALUE
MAYAGUEZ - HORMIGUEROS STUDY AREA			
1	Guanajibo Homes (Along HWY. 102)	\$ 61,415	\$ 19,653
2	San José Development (HWY. 102)	61,483	18,445
	Ramírez de Arrellano (HWY. 102)	50,290	15,087
	Vista Verde Development (HWY. 2)	64,750	19,425
3	Parcelas Castillo (HWY. 114)	30,716	9,215
	Guanajibo Gardens (Besides Industrial Park)	27,720	9,702
4	Buenaventura Dev. (HWY. 114)	61,628	17,872
	Valle Hermoso Development	49,000	17,150
5	San Romualdo Community	34,096	11,900
6	Residential Structures along HWY. 345	30,000	10,200
SAN GERMAN STUDY AREA			
1	Res. Along HWY. 347	24,760	7,428
2	Res. Along North Bank (HWY. 360 - HWY. 119)	24,730	7,420
5	Res. Along Cross Sect. 16 to Bridge on HWY. 360	55,720	16,716
8	Vivoni & Other Developments	60,466	18,140
9	Santa María & Riverside Developments	56,264	16,880
10	North Bank-East of HWY. 119 Sector	57,027	17,108
11	West Bank Sector	24,734	7,420

*Some reaches do not have residential developments.

2. Other land uses. Structure values for commercial, public, utilities, and industrial land uses were based on appraisal data developed for the survey reports mentioned above. A professional appraiser was contracted by the Real Estate Division to do value assessments during 1990. Contents values were assessed by means of a comparative analysis with similar category establishments for which actual values were obtained through a field investigation conducted on a 100 percent of the commercial establishments within the study area of the Upper Río Grande de Loíza basin. A similar approach was followed for other land use categories within the flood plain.

Table E-6 shows total value of structure and contents by land use categories, utilized for determining flood damages in each of the study areas.

3. Other property (external to main structure). This property refers to lawns, yards, parking areas, fences, automobiles, and other facilities outside the main structures. Values for this property were obtained through field visits and were integrated with the various land uses.

E. Depth-Damage Relationships

Depth-damage relationships for the residential, commercial, and public land uses developed for the Río Puerto Nuevo Survey Report (Jacksonville District, 1984) and the Río Cibuco Detailed Project Report (Jacksonville, 1982), were utilized to estimate flood damages for existing development. Damage curves were developed using historical data on flood damages throughout the island.

Depth-damage curves on a percentage basis were developed for the residential and commercial land uses and for public schools. Available historical damage data for comparable areas throughout the island allowed the establishment of relationships between depth of water and percentage damage potential to structure and contents for residential, commercial, and school facilities. Such data were not available for some land uses and the depth-damage relationships were established on an absolute basis from information provided by representatives of those land uses.

1. Residential. To determine the damage susceptibility of residential structures, the actual damages to 250 comparable structures throughout Puerto Rico during the floods of Eloise (1975) were analyzed. The data was obtained from the Damage Survey Reports (DSR) of the Federal Disaster Assistance Administration known today as the Federal Emergency Management Agency (FEMA). Damages were repaired under the Minimum Repair Program of that agency. For each residential structure the cost of replacing or repairing the structural damages was divided by the total estimated value of the structure. A minimum-least-squares curve of the percentages of structural damages related to the depth of water was fitted to the data. The curve was used to determine structural damages to all residential structures within the flood plain. Most of the structural damages are to the following categories: electric system, plumbing system, windows, doors, air conditioning units, water heaters, kitchen cabinets, built-in stoves and ovens, bathroom fixtures, wall-to-wall carpeting, paint, and other furnishings. The foundations and the

TABLE E-6

RIO GUANAJIBO FEASIBILITY REPORT

SUMMARY OF TOTAL STRUCTURE AND CONTENT VALUES BY LAND USES
(\$1,000 of 1994)

DESCRIPTION	STRUCTURE VALUES	CONTENT VALUES
M A Y A G U E Z - H O R M I G U E R O S A R E A		
Residential	\$131,026,003	\$40,118,392
Commercial	5,440,450	7,229,360
Public	3,928,540	590,240
Non-profit	1,465,200	216,000
Utilities	104,400	225,000
S A N G E R M A N A R E A		
Residential	\$26,275,880	\$7,884,236
Commercial	5,446,500	7,176,900
Public	5,253,250	4,389,300
Non-profit	149,400	19,840
Utilities	900,800	650,000

structures do not suffer significant damages because they are primarily built of reinforced concrete. These are affected mostly in areas near the river banks where velocities are significant. Due to lack of data, relationships between velocities and damage potential could not be developed and were not considered. To determine residential contents damage susceptibility, actual damages to contents in 30 residential structures in the Puerto Nuevo area during the 1977 flood were analyzed. These data were obtained from the Small Business Administration records on disaster loans to residents in the area and from records of flood insurance policy claims from the National Flood Insurance Program (NFIP). The value of contents damaged was divided by estimates of the total value of contents, and a minimum-least-square regression of percentage of contents damages to depths of water was fitted to the data. This curve was then used to determine damages from different flood stages to the contents of residences throughout the flood plain. The historical depth of water was obtained from the U. S. Geological Survey records and from residents of the area. The curves were updated in 1987 using actual flood damages to 98 housing structures from the 1985 floods along the Río Cibuco. On the basis of field surveys, average first floor elevation is generally taken to be about 1 foot for residential areas. Figure E-1 shows the residential depth-damages curves.

2. Commercial establishments. Curves derived for the various categories of commercial establishments for the Río Puerto Nuevo area were developed by a professional appraiser with considerable experience in investigating claims under the National Flood Insurance Program (NFIP).

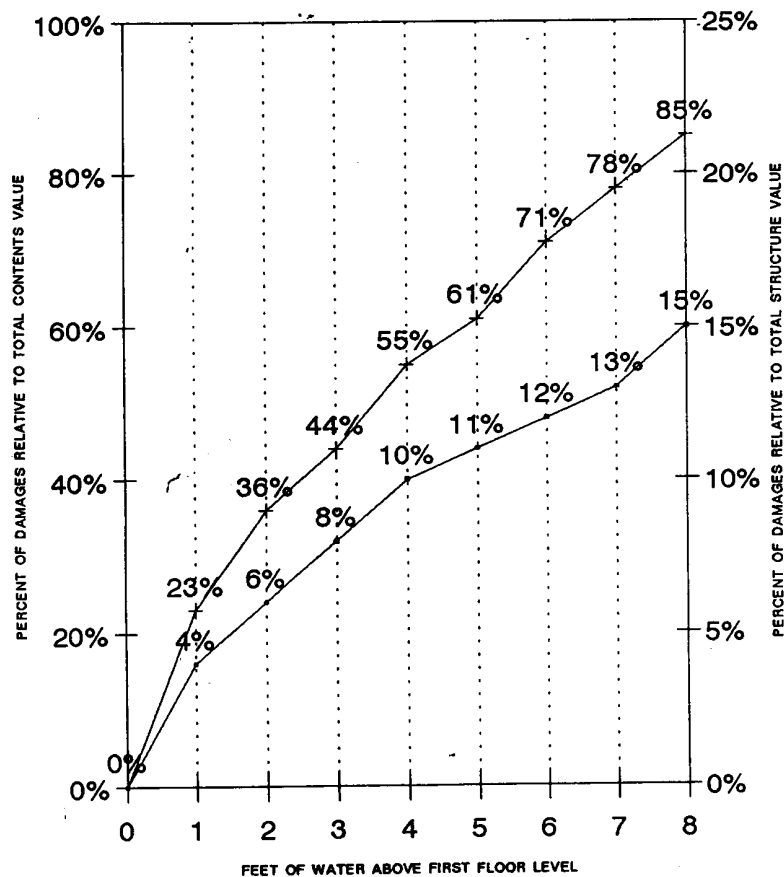
Average damages in terms of a percentage were determined by the analysis of claims under the NFIP. Empirical data were used to develop damages for floodwaters of a depth less than 1.2 meters. Percentage figures for damages occurring at depths over 1.2 meters were estimated by the appraiser on the basis of professional judgment. Although similar in nature, different types of businesses show different contents damage percentages since the merchandise is displayed differently. For commercial facilities, major structural damages consist of the electrical system, plumbing facilities, door, windows, air conditioning units, and other furnishings.

In some instances a total loss at depths of 1.2, 2.1, or 2.4 meters has been considered. In other cases total loss does not occur at this depth. The average floor-to-ceiling height in an average commercial building is between 2.4 and 3.1 meters, while other types of businesses have higher ceilings and some property is stored or placed above 2.4 meters.

Figures E-2 through E-7 present the depth-damage percentage relationships for the various commercial categories.

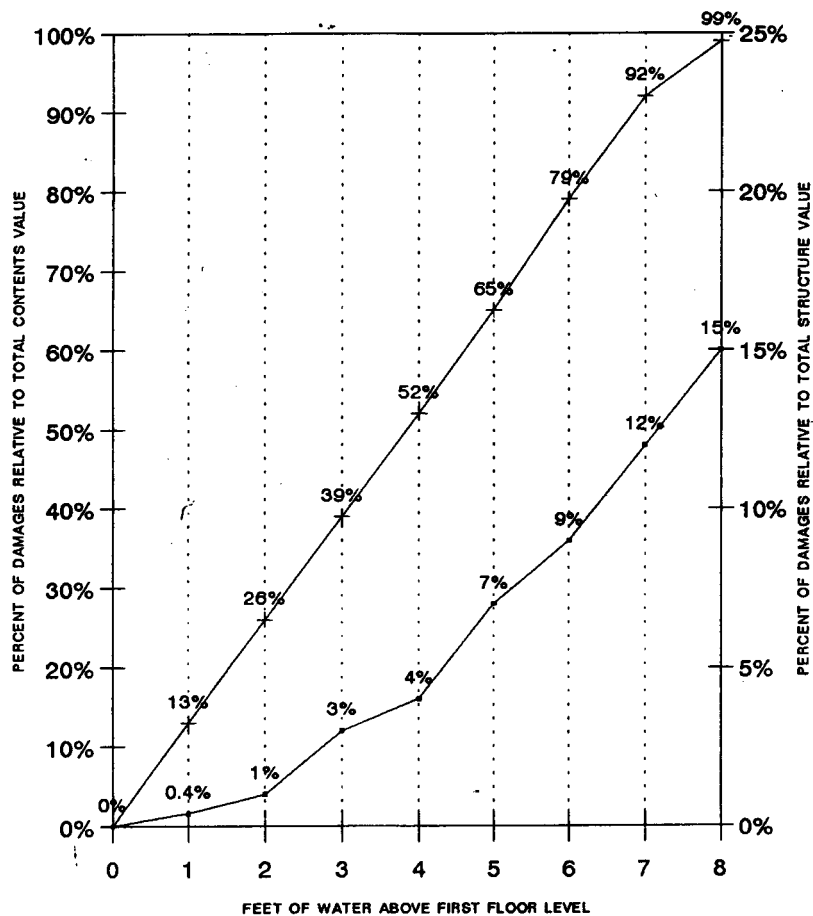
3. Public buildings and offices. Damage estimates to structure and contents of public buildings and offices were ascertained using the depth-damage relationship developed for elementary schools. For school buildings, data provided by the Superintendent of Schools, the school directors, the Public Buildings Authority, and the General Services Administration were used to develop basic depth-damage relationships. Figures E-8 and E-9 shows damage curves for school facilities.

DEPTH DAMAGE RELATIONSHIP FOR RESIDENTIAL LAND USE



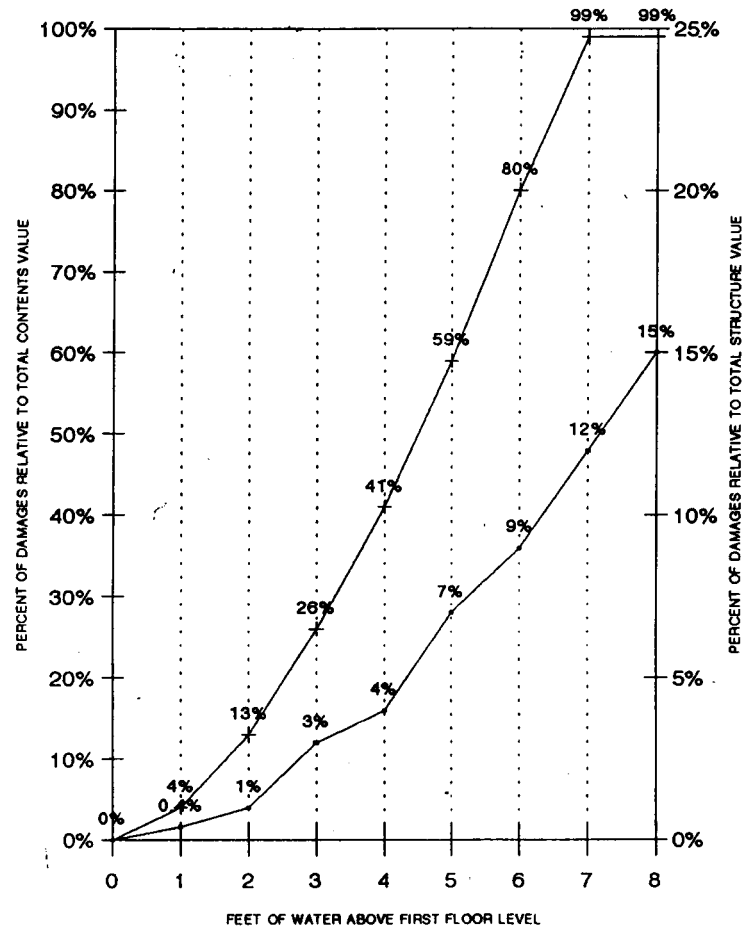
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DEPHT DAMAGE RELATIONSHIPS COMMERCIAL CATEGORY 1

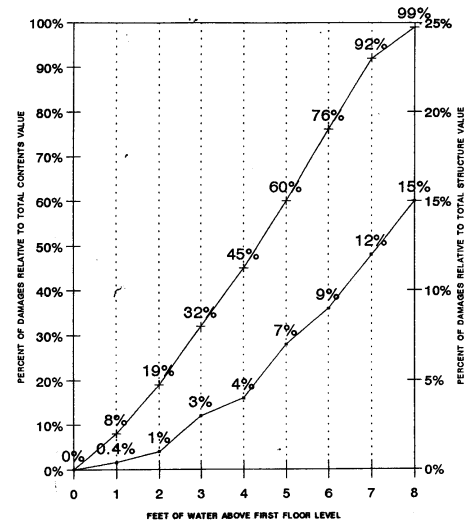


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DEPHT DAMAGE RELATIONSHIPS COMMERCIAL CATEGORY 2



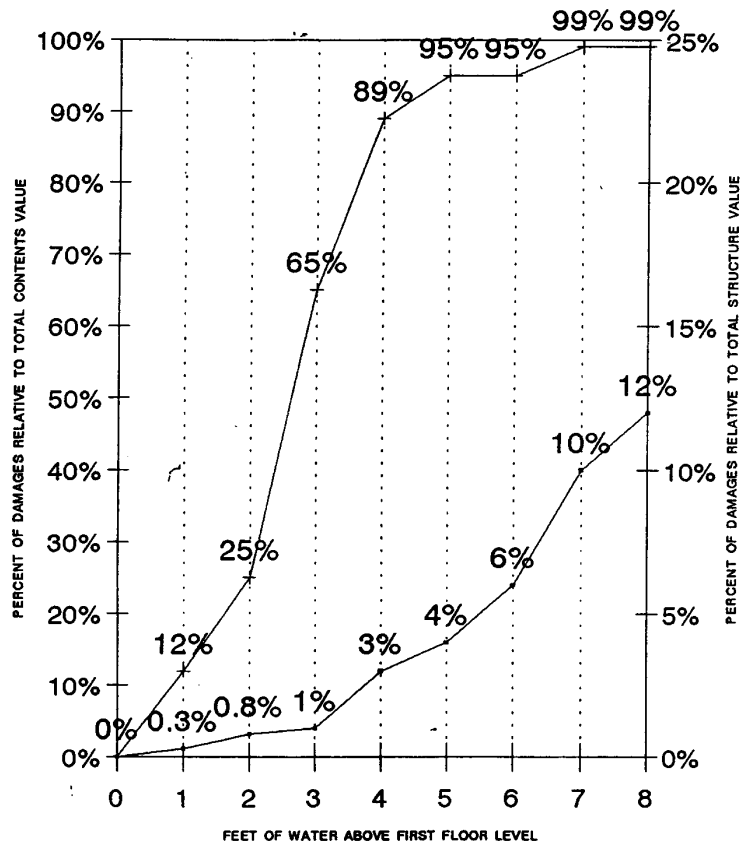
— STRUCTURE — CONTENTS

DEPHT DAMAGE RELATIONSHIP
COMMERCIAL CATEGORY 3

+ STRUCTURE + CONTENTS

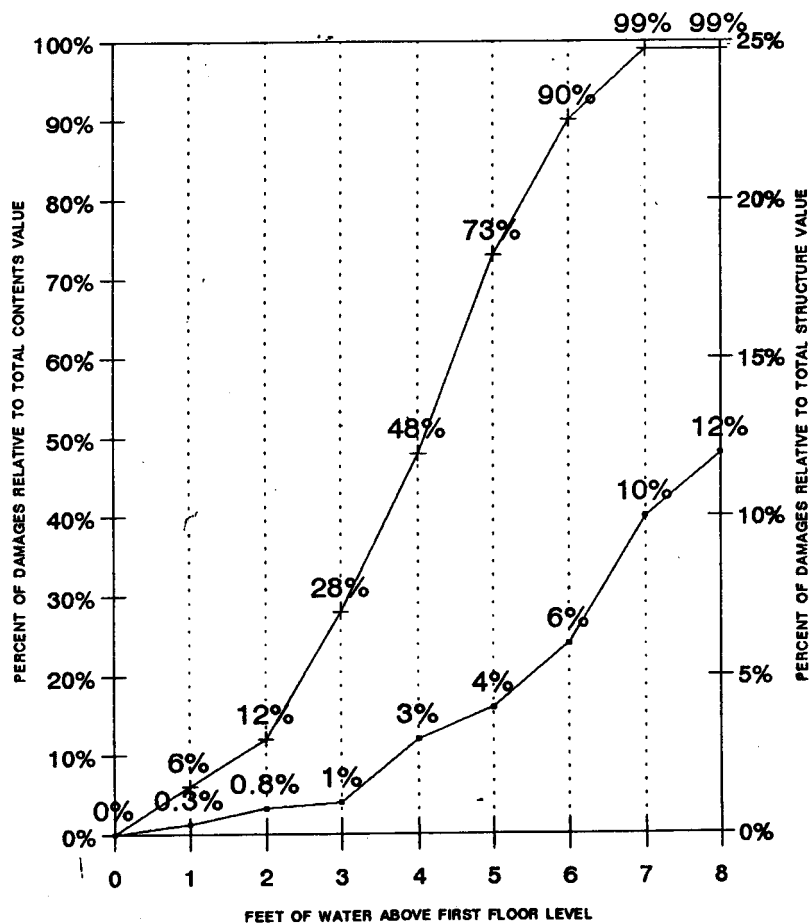
U.S. ARMY CORPS OF ENGINEERS

DEPTH DAMAGE RELATIONSHIP
COMMERCIAL CATEGORY 4



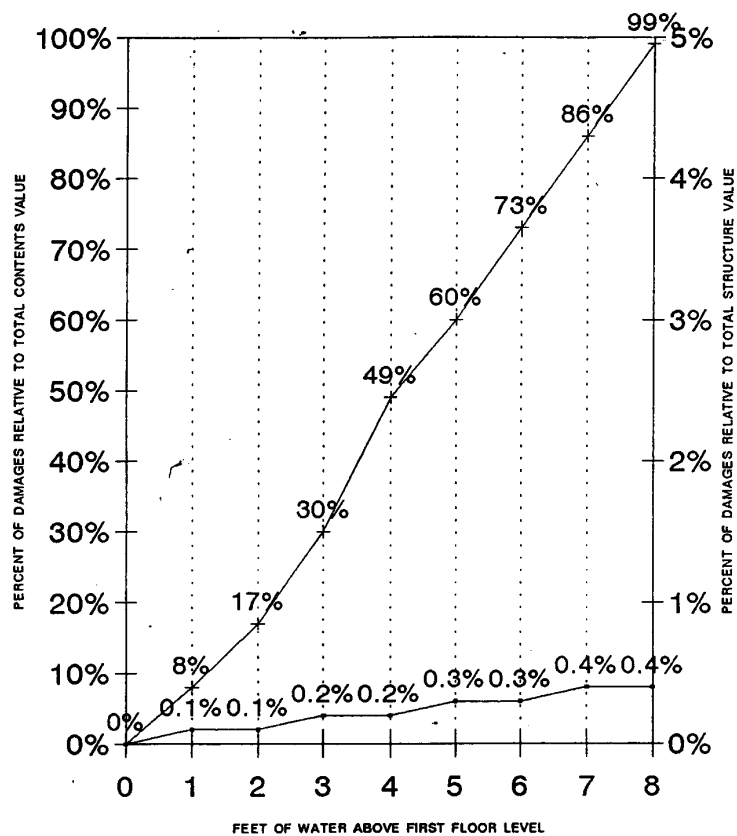
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DEPTH DAMAGE RELATIONSHIP COMMERCIAL CATEGORY 6



— STRUCTURE + CONTENTS

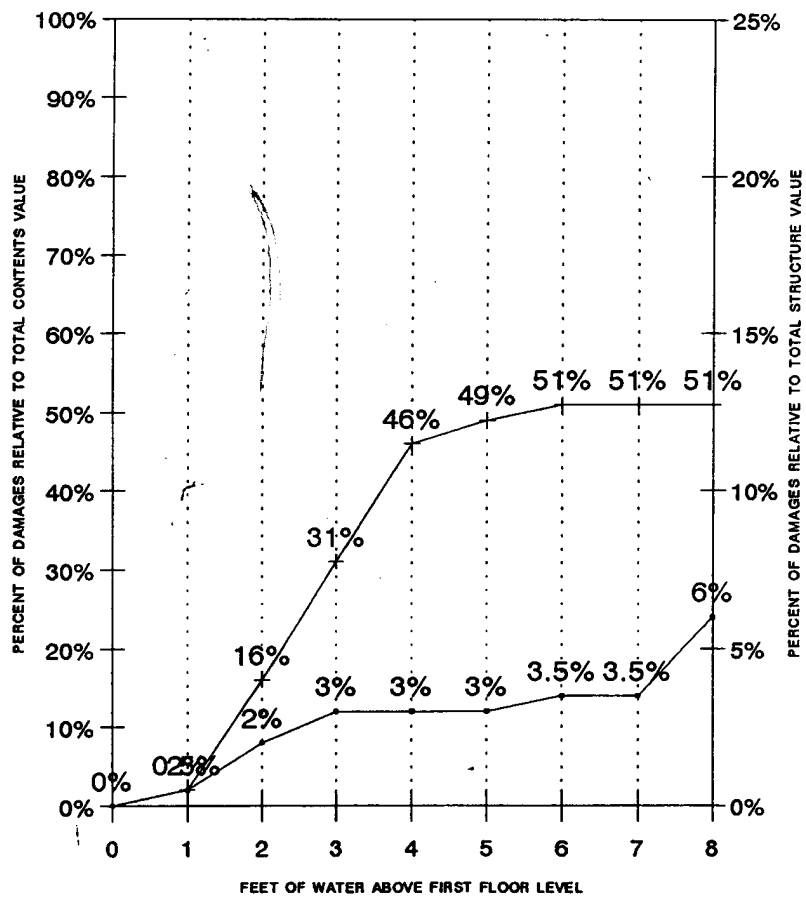
DEPTH DAMAGE RELATIONSHIP COMMERCIAL CATEGORY 8



—•— STRUCTURE —+— CONTENTS

US ARMY CORPS OF ENGINEERS

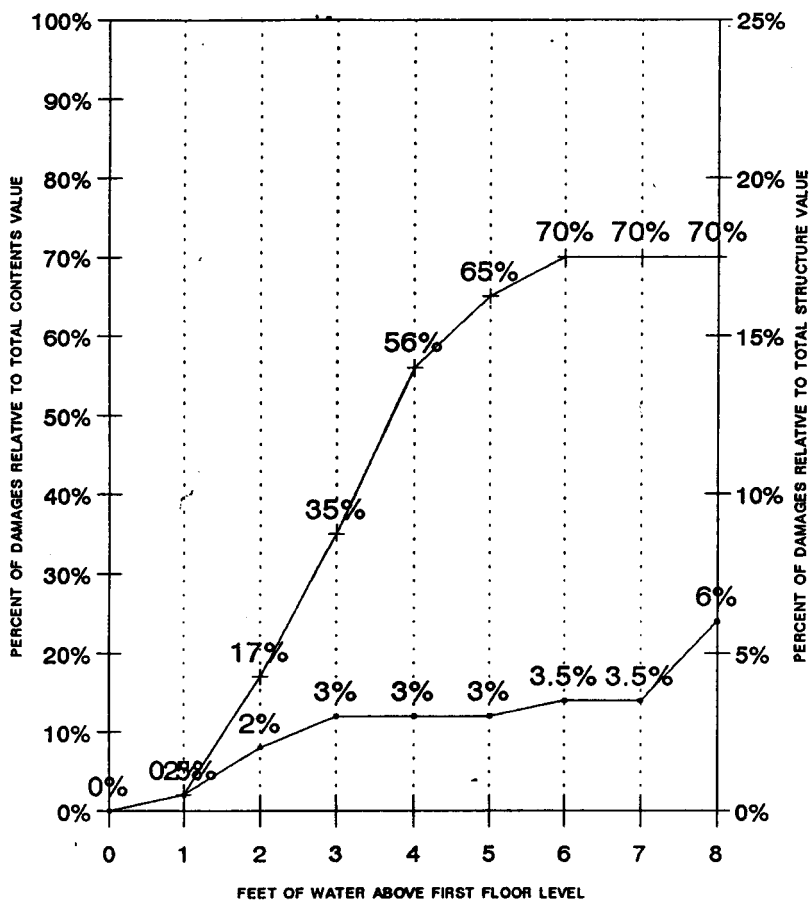
DEPHT DAMAGE RELATIONSHIP PUBLIC CATEGORY 9 (ELEMENTARY SCHOOLS)



— STRUCTURE — CONTENTS

US ARMY CORPS OF ENGINEERS

DEPTH DAMAGE RELATIONSHIP
PUBLIC CATEGORY 10 (SECONDARY SCHOOLS)



— STRUCTURE — CONTENTS

US ARMY CORPS OF ENGINEERS

4. Nonprofit organizations. Damage potential to the structures and contents of these facilities are shown in Figure E-10.

5. Utilities. Cleanup and repair costs for water, sewage, electric, gas and telephone lines, meters, and power stations were estimated at \$2,000 per 4,000 square meters of developed land in the flood plain. These figures are based on field observations and discussions with representatives from the various utilities companies.

6. Highways and streets. Damage to highways and streets were estimated applying a percentage of the cost of repair per kilometer to the number of kilometers flooded for each flood frequency analyzed. Damage per kilometer was developed through discussions with officials of the San Juan Regional Office of the Department of Transportation and Public Works (DTPW). Analysis of current highway construction and repair costs were obtained from a variety of sources. In accordance with the DTPW, the total cost of repairing a badly damaged two-lane highway is \$79,600 per kilometer. Damages to highways during the SPF, 100-, 50-, 25-, and 10-year flood events were estimated at \$64,000, \$48,000, \$32,000, \$16,000, and \$8,000 per kilometer, respectively. Damages to streets were estimated at 50 percent of the highway damage per kilometer.

F. Flood Damages

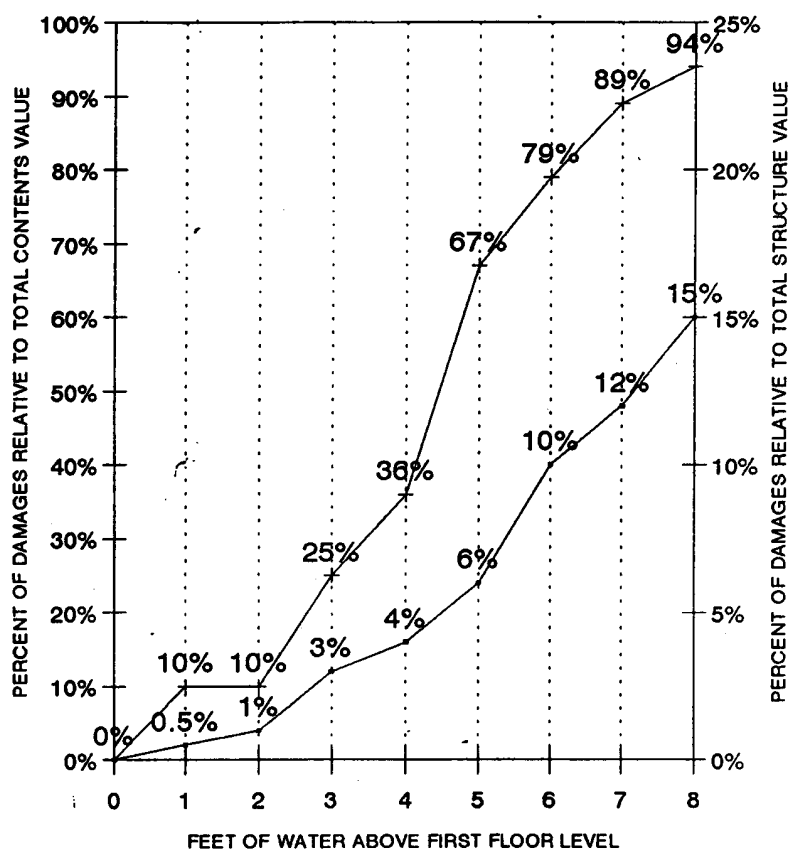
1. General. This section presents historical flood damages data for the study area and potential damage for selected flood frequencies and land uses identified in the flood plain.

2. Historical damages. Historical damages within the cities of Mayagüez and San Germán and its vicinity were obtained through the Municipal Civil Defense. A summary of the damages for the 1985 event are depicted in Table E-7. A review of the discharges associated with that event shows that the flood had a recurrence interval of approximately ten years. Damages reported refer almost exclusively to structure contents. It is understood that damage assessments during emergency conditions do not follow a rigorous procedure; thus, historical damages shown are grossly underestimated and are included as a general reference only. Photos 1 to 4 show some of the physical damage associated with flooding in the study area during Hurricane Eloise in 1975. Annex E-1 to this appendix provides more information on damages associated with the 1975 floods.

3. Potential total and average annual damage. Flood damages by flood frequency for residential, commercial, public, and nonprofit land uses are estimated utilizing a computer program developed at the San Juan Area Office which applies the appropriate depth-damage relationships to value of structure and contents of different land uses considering the depth of water in each particular reach.

The Expected Annual Flood Damages Computation Model developed by the Hydrologic Engineering Center, U. S. Army Corps of Engineers, was then applied to obtain average annual equivalent damages for existing, future, and with project conditions. Potential damage is estimated using 1994 price level for structure and content values and is discounted at 8.0 percent interest rate for the first 50 years of the project life.

DEPTH DAMAGE RELATIONSHIP NON-PROFIT LAND USE



— STRUCTURE — CONTENTS

TABLE E-7
RIO GUANAJIBO FEASIBILITY STUDY

HISTORICAL DAMAGES¹

FOR THE CITY OF HORMIGUEROS (GUANAJIBO, VALLE HERMOSO DEVELOPMENT)	
FLOOD EVENTS	TOTAL DAMAGES
September 1975	\$9,443,976
August 1979	1,163,493
September 1982	21,000
September 1984	26,000
May 1985	46,475
October 1985	419,000
FOR GUANAJIBO HOMES IN THE CITY OF MAYAGUEZ	
FLOOD EVENT: September 1975	
DAMAGE CLASSIFICATION	AMOUNT REPORTED ² (Dollars 1975)
Residential for Guanajibo Homes (Contents)	\$ 39,122
Other Damages:	\$103,573
Municipal Vehicles	14,080
Heavy Equipment	29,700
Debris on the Bank	2,200
Debris from Guanajibo Homes, Guanajibo Gardens, Parcelas Castillo, and El Maní	57,593
Aqueduct and Sewers Authority	8,752
Total Damages:	\$151,447

¹Source: Civil Defense, municipal governments of Hormigueros and Mayagüez.

²Amounts reported do not include damages to streets, roads, and structures.



Photo 1
Residential Area at Mayaguez-
Hormigueros Area Flood Damages
September 16, 1975 during Hurricane
Eloise



Photo 2

Floods of September, 1975
Hurricane Eloise

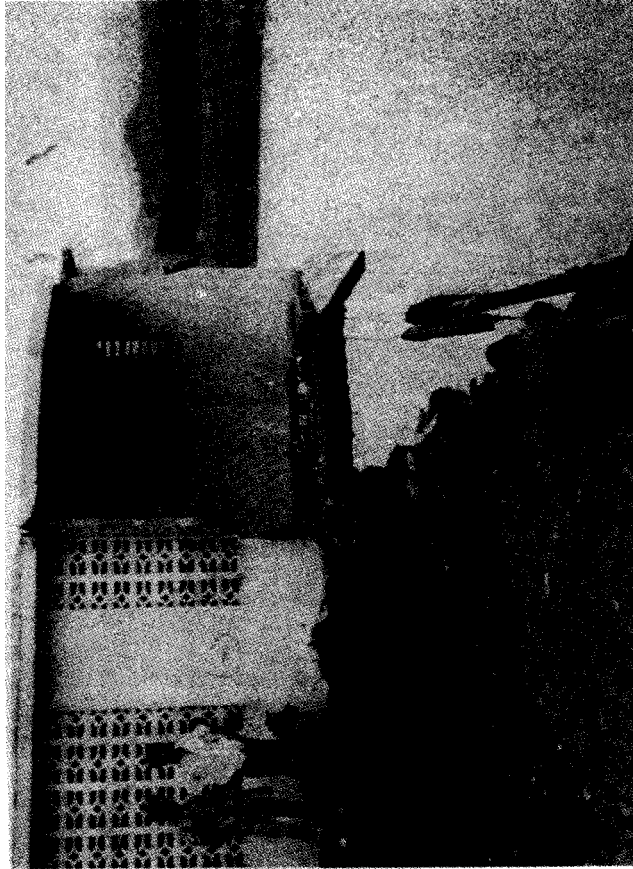


Photo 3

Damage to Residential Structure
Floods of September 1, 1975



Photo 4

Extensive Flooding
during September, 1975
Hurricane Eloise

a. Existing conditions (1994). Table E-8 shows flood damage estimates for selected flood frequencies and land use categories under existing conditions for the Mayagüez-Hormigueros area and for the San Germán area, respectively. Total damage for the Mayagüez-Hormigueros study area range from \$914,000 for the 2-year flood to \$50,939,000 for the 100-year. Corresponding figures for the San Germán study area are \$8,000 and \$18,420,900. The residential land use is the most affected. It is also observed that damages to commercial, public schools, and other public buildings are appreciable for the higher frequency events. Average annual damage for existing conditions for the Mayagüez-Hormigueros area is \$4,821,000 while for the San Germán area it is \$1,117,000.

b. Future conditions. Increased flood damage for future conditions only reflect the application of the affluency factor to existing household contents values as specified in the Principles and Guidelines for Water and Related Land Resources. This document requires that affluence considerations be limited to 50 percent of a structure's current value. The projected annual growth rate of real per capita disposable income was utilized to measure future changes in residential contents. A figure of 3.4 percent, based on historical trend and provided by the Puerto Rico Planning Board, was utilized for this estimate.

Expected Annual Equivalent Damages as of base year 2000 for the without project conditions for both detailed study areas are shown in Table E-9. The residential land use sustains most of the damage (over 95 percent).

IV. NATIONAL ECONOMIC DEVELOPMENT BENEFITS

A. General

This section describes the procedures utilized to estimate the various categories of National Economic Development Benefits considered for assessing and evaluating the flood control plans developed for the Mayagüez-Hormigueros area and the San Germán area. It also presents aggregate cost data of the plans considered. Details on the plans considered are in the Main Report while cost estimates are in Appendix C, Design and Cost Estimates.

Only inundation reduction benefits for all types of structures and land uses are used in evaluating the preliminary and final plans. Consideration of other types of benefits do not alter the plan formulation and recommendation process. For the economics of the recommended plan, other benefit categories considered are employment, advance bridge replacements, flood insurance savings, and recreational. The cost side of the plans considered includes construction costs; engineering, design, supervision, and administration costs; real estate costs; interest during construction; and operation and maintenance costs.

B. Synthesis of Preliminary and Final Plans

For the Mayagüez-Hormigueros area three preliminary plans are considered:

TABLE E-8

RIO GUANAJIBO FEASIBILITY REPORT

POTENTIAL DAMAGE FOR SELECTED FLOOD EVENTS
 1994 WITHOUT PROJECT CONDITIONS
 FOR THE MAYAGUEZ-HORMIGUEROS, AND SAN GERMAN AREAS
 (\$1,000 of 1994)

MAYAGUEZ-HORMIGUEROS AREA			
LAND USE	F L O O D F R E Q U E N C Y		
	2-YEAR	25-YEAR	100-YEAR
Residential	\$699	\$26,858	\$42,283
Commercial	0	2,820	5,570
Public	0	371	539
Non-profit	0	59	96
Streets/Highways	43	158	187
Utilities	172	1,443	2,264
Total	\$914	\$31,709	\$50,939
Average Annual Damage: \$4,821			
SAN GERMAN AREA			
Residential	\$0	\$7,472	\$11,124
Commercial	0	1,412	5,224
Public	0	535	1,244
Non-profit	0	19	35
Streets/Highways	0	67	317
Utilities	8	255	476
Total	\$8	\$9,760	\$18,420
Average Annual Damage: \$1,117			

TABLE E-9

RIO GUANAJIBO FEASIBILITY REPORT

POTENTIAL DAMAGE FOR SELECTED FLOOD EVENTS
WITHOUT PROJECT CONDITIONS AT BASE YEAR 2000
FOR THE MAYAGUEZ-HORMIGUEROS, AND SAN GERMAN AREAS
(\$1,000 of 1994)

MAYAGUEZ-HORMIGUEROS AREA			
LAND USE	F L O O D F R E Q U E N C Y		
	2-YEAR	25-YEAR	100-YEAR
Residential	\$ 799	\$30,251	\$47,374
Commercial	0	2,820	5,570
Public	0	371	539
Non-profit	0	59	96
Streets/Highways	43	158	187
Utilities	172	1,443	2,264
Total	\$1,014	\$35,102	\$56,030
Average Annual Equivalent Damage: \$5,738			
SAN GERMAN AREA			
Residential	\$0	\$8,323	\$12,376
Commercial	0	1,412	5,224
Public	0	535	1,244
Non-profit	0	19	35
Streets/Highways	0	67	317
Utilities	8	255	476
Total	\$8	\$10,611	\$19,672
Average Annual Equivalent Damage: \$1,318			

Plan 1. This plan is generally a continuous levee system from the coast to upstream Highway 100 to protect against the 100-year flood event, all the developed area along the southern edge of the Mayagüez-Hormigueros metropolitan area. A ring levee is suggested to protect the Guanajibo Homes located in the vicinity of the mouth of the river (refer to related plates of the Main Report).

Plan 2. This plan suggests several segments of levees to protect the same areas as Plan 1 against the same flood (refer to plates of the Main Report).

Plan 3. This plan provides the same degree of protection (100-year flood) to the same area with channel improvements to Río Guanajibo from the mouth to upstream Highway 100 (refer to plates of the Main Report).

Since all these plans provide the same degree of protection, they result in the same amount of inundation damages reduction or inundation damages benefits.

On the basis of economic and environmental considerations, Plan 2 appeared as the most attractive plan for final consideration. Two other similar plans, one protecting for 50-year and the other protecting for SPF were also considered as final plans. Details on the design characteristics and impacts of the aforementioned plans are presented in the Main Report and in Appendix H, Hydrology and Hydraulics.

In the case of San Germán, four preliminary plans are considered:

Plan 1. This plan consists of a concrete rectangular channel and levee designed to protect the developed area of San Germán between Highways 360 and 119 from the 100-year event.

Plan 2. This plan will protect the same area and provide the same degree of protection as Plan 1 but with a levee.

Plan 3. This plan consists of a levee system along both banks of the river to protect developed areas from the 25-year flood.

Plan 4. This plan consists of gabion channel improvements to protect against the 10-year flood. The plan also includes the replacement of the bridge on Highway 119.

On the basis of economic analysis, Plans 1 and 2 were not justified. Plan 3 has operational and safety concerns that may lead to false assumptions on flood protection within the community that could result in catastrophic results. Therefore, Plan 4 was the only plan selected for final consideration for the San Germán area as the most attractive plan. This was based on the economic analysis and also to avoid inaccurate expectations of security as mentioned above.

Details on the design criteria and impact of the aforementioned plans for the San Germán area are also presented in the Main Report and in Appendix H, Hydrology and Hydraulics.

C. Categories of Benefits Considered

1. Inundation reduction and residual flooding damage. Reduction of physical damages to property, experienced by occupants of the flood plain, are considered a contribution to income at the national level. The difference between expected physical annual damages expressed in monetary terms under the with and without projects conditions for each plan was taken as the contribution (the benefits) of that plan. Damages reduced are taken up to the level of protection afforded by a particular plan. Appropriate multiple frequency computations of hydrologic and hydraulic conditions and stage-damage relationships were used to estimate physical flood damages in the area.

Inundation reduction benefits and residual flooding damage for each of the preliminary and final plans are presented for the Mayagüez-Hormigueros area and for the San Germán area in Table E-10.

2. Other categories of benefits. As noted above, these are other categories of benefits in addition to the inundation benefits that are considered to establish the economics of the recommended plan. They are briefly described below.

a. Employment. The use of unemployed labor resources that would have remained unemployed in the absence of a plan is considered a project benefit. The NED benefit is limited to payments to unemployed and underemployed labor resources directly employed in the construction and installation of the project and also includes labor used for operations and maintenance.

Traditionally, the unemployment rate in Puerto Rico has been very high. Between 1975 and 1986 it averaged about 19 percent. More recently, it has come down to about 15 percent. High unemployment is still one of the major socioeconomic problems in Puerto Rico. In 1993 the construction industry, which constitutes one of the dynamic sectors of the economy, accounted for about 48,000 jobs of a total work force of 900,000. There is a considerable pool of unemployed persons, some of whom could be employed in the event of the construction of a flood control project.

For determining the portion of construction labor cost allocated to the unemployed, it was assumed that 20 percent of the total construction cost of a project would be used for the wages and salaries of the construction workers. This figure was arrived at on the basis of information provided by representatives of the local private construction industry contacted through telephone calls, data obtained from the Unemployment Insurance Bureau of the Puerto Rico Department of Labor and Human Resources, and general familiarity with the ongoing Portugués and Bucaná Flood Control Project (currently being built by the Corps of Engineers in the Ponce Metropolitan Area), which shows comparable labor characteristics to the study area labor market.

TABLE E-10
RIO GUANAJIBO FEASIBILITY REPORT
INUNDATION REDUCTION BENEFITS AND RESIDUAL FLOODING
FOR PRELIMINARY AND FINAL PLAN
(\$ in \$1,000 of 1994)

PLAN	MAIN CHARACTERISTICS	DEGREE OF PROTECTION	INUNDATION BENEFIT	RESIDUAL FLOODING
MAYAGUEZ-HORMIGUEROS AREA				
PRELIMINARY				
Plan 1	Continuous Levee	100-Year	\$5,256	\$482
Plan 2	Discontinuous Segments of Levee	100-Year	5,256	482
Plan 3	Channel Improvement	100-Year	5,256	482
FINAL				
Plan 1	Discontinuous Segments of Levee	50-Year	4,773	965
Plan 2	Discontinuous Segments of Levee	100-Year	5,256	482
Plan 3	Discontinuous Segments of Levee	SPF	5,513	225
SAN GERMAN AREA				
PRELIMINARY				
Plan 1	Channel Improvement	100-Year	\$1,245	\$ 73
Plan 2	Levee	100-Year	2,219	99
Plan 3	Levee	25-Year	878	440
Plan 4	Channel Improvement	10-Year	700	618
FINAL				
Plan 1	Channel Improvement	10-Year	\$ 700	\$618

To determine the relative amount and classification of labor, an analysis of the construction schedule at each river stream was made. The percentage distribution for the various categories is as follows:

Skilled	-	60
Unskilled	-	10
Others	-	30

These percentages were determined from actual data for the Portugués and Bucaná channel improvements project. They were assumed to remain constant during the construction phase due to the nature of the project.

Wages and salaries used to employ workers drawn from the unemployed pool for each category of workers were determined on the basis of an analysis of empirical data from the Portugués and Bucaná channel improvements project. Percentages determined are as follows:

Skilled	-	80%
Unskilled	-	80%
Others	-	50%

The benefits figures are then annualized at 8 percent rate for the 50-year period.

b. Advance bridge replacement. This category reflects benefits to be derived from replacing bridges that have not served all their economic life. Benefits were estimated on the basis of the estimated costs of the new bridges and the number of years that their economic life would be extended as a result of the replacement.

c. Flood insurance overhead benefits. The savings in administrative costs of flood insurance are also included as a beneficial effect of a flood control project. Annual administrative costs for flood insurance policies for fiscal year 1993 were estimated to be \$112 per policy.

To determine the benefits of the reduction in flood insurance costs for Río Guanajibo, the total number of policies in force for Puerto Rico were obtained from the Federal Emergency Management Agency (FEMA), Region II. Since Puerto Rico is considered "a community," as defined by the National Flood Insurance Program, the data obtained is for policies issued island-wide. This total number of policies was converted to an urban per structure basis. The conversion was established since special flood hazard areas and flood insurance maps are only available for flood prone areas in the urban zones of Puerto Rico. The number of policies was then applied to the urban structures of the areas of Mayagüez-Hormigueros and San Germán. A further correlation between the number of policies associated with these urban areas and the share corresponding to each protection plan was obtained by weighing those policies against the total number of structures affected by the 100-year flood for the with and without project conditions.

D. Benefits, Cost Estimates, and Risk Based Analysis

1. Cost estimates. Table E-11 shows at the aggregate level cost estimates for the preliminary and final plans for the Mayagüez-Hormigueros area. These cost figures reflect 1993 price level. Table E-12 shows similar data for the San Germán area.

2. Net benefit analyses. Table E-13 summarizes for each of the two areas (the Mayagüez-Hormigueros area and the San Germán area) the benefits and costs associated with each of the preliminary and final plans considered. Benefits relate only to inundation reduction benefits. The benefits associated with preliminary plans in the Mayagüez-Hormigueros area are the same because each provides the same degree of protection. On the basis of the criteria of the maximum contribution to NED, environmental enhancement, and social well-being, Plan 2 of the final plans was selected as the final plan for further analysis in the Mayagüez-Hormigueros area and Plan 4 of the preliminary plans in the San Germán area. (Refer to Chapter VIII, Description and Analysis of Final Plans of the Main Report.)

3. Risk Based Analysis. Before finalizing the recommended plan, including undertaking an incremental analysis of the various levee segments in the Mayagüez-Hormigueros area suggested under the most attractive final plan, a risk based analysis regarding uncertainty on economic, hydrology and hydraulic estimates was undertaken for the final plans in the Mayagüez-Hormigueros area following EC-1105-2-205. Risk and Uncertainty underlying hydrology and hydraulic estimates are discussed in Appendix A. The analysis does not include uncertainty associated with costs estimates. The analysis was conducted in part with the assistance of staff from the Institute of Water Resources (IWR) and the Hydrologic Engineering Center (HEC). In the case of the economic estimates, potential risk and uncertainty was examined through a proportional random sample of 73 observations for estimating errors associated with value of structure, value of content, and the first floor elevation of residential structures in the Mayagüez-Hormigueros area. Residential structures make up over 95 percent of total structures and facilities in the flood plain. The variation underlying these estimates was estimated for each damage reach in the Mayagüez-Hormigueros area to be as follows:

DAMAGE ERROR ESTIMATES FOR RISK ANALYSIS

DEVELOPMENT	STANDARD DEVIATION FOR		
	AVERAGE VALUE OF STRUCTURE PER UNIT	AVERAGE VALUE OF CONTENT PER UNIT	AVERAGE FIRST FLOOR ELEVATION
GUANAJIBO HOMES/SAN JOSE DEVELOPMENTS			
Guanajibo Homes	\$ 5,190	\$ 2,992	0.25
San José	2,033	1,987	0.25
Ramírez de Arellano	13,111	3,033	0.25
Vista Verde	2,000	2,000	0.25
VALLE HERMOSO/BUENAVENTURA DEVELOPMENTS			
Buena Ventura	7,554	3,632	0.24
Valle Hermoso	8,566	2,722	0.24
San Romualdo	6,100	3,900	0.25

TABLE E-11
RIO GUANAJIBO FEASIBILITY REPORT

SUMMARY OF COSTS FOR THE PRELIMINARY AND FINAL PLANS
FOR THE MAYAGUEZ-HORMIGUEROS AREA
(\$1,000 OF 1993)

P R E L I M I N A R Y P L A N S			
DESCRIPTION	PLAN 1 (100-Year) Levee	PLAN 2 (100-Year) Levee	PLAN 3 (100-Year) Channel
Construction Cost	\$18,849	\$17,670	\$67,206
Planning, Engineering, Design, and Construction Management	3,604	3,380	10,081
Real Estate	7,677	6,044	4,770
Total First Cost	\$30,130	\$27,094	\$82,057
Interest During Construction	1,544	1,448	9,372
Total Investment Cost	\$31,674	\$28,542	\$91,429
Annual Investment Cost	2,584	2,333	7,475
Operations and Maintenance	60	60	80
Total Annual Cost	\$ 2,649	\$ 2,393	\$ 7,555
F I N A L P L A N S			
DESCRIPTION	PLAN 1 (50-Year) Levee	PLAN 2 (100-Year) Levee	PLAN 3 (SPF) Levee
Construction Cost	\$15,003	\$17,670	\$20,681
Planning, Engineering, Design, and Construction Management	2,874	3,380	3,952
Real Estate	5,558	6,044	6,648
Total First Cost	\$18,435	\$27,094	\$31,281
Interest During Construction	889	1,448	2,264
Total Investment Cost	\$24,024	\$28,542	\$33,545
Annual Investment Cost	1,964	2,333	2,742
Operations and Maintenance	60	60	60
Total Annual Cost	\$ 2,024	\$ 2,393	\$ 2,802

TABLE E-12
RIO GUANAJIBO FEASIBILITY REPORT
SUMMARY OF COSTS FOR THE PRELIMINARY AND FINAL PLANS
FOR THE SAN GERMAN AREA
(\$1,000 of 1993)

DESCRIPTION	PRELIMINARY PLANS			
	PLAN 1 (100-Year Channel)	PLAN 2 (100-Year Levee)	PLAN 3 (25-Year Levee)	PLAN 4 (10-Year Channel)
Construction Cost	\$27,389	\$12,884	\$6,561	\$5,562
Planning, Engineering, Design, and Construction Management	4,108	1,933	1,247	\$1,057
Real Estate	1,255	1,515	2,010	680
Total First Cost	\$32,752	\$16,332	\$9,818	\$7,299
Interest During Construction	1,783	1,090	442	375
Total Investment Cost	\$34,535	\$17,422	\$10,260	\$7,674
Annual Investment Cost	2,823	1,424	839	627
Operations and Maintenance	40	40	30	20
Total Annual Cost	\$2,863	\$1,464	\$ 869	\$ 647
FINAL PLAN				
DESCRIPTION	PLAN 4 (10-Year Channel)			
Construction Cost	\$5,562			
Planning, Engineering, Design, and Construction Management	1,057			
Real Estate	680			
Total First Cost	\$7,299			
Interest During Construction	375			
Total Investment Cost	\$7,674			
Annual Investment Cost	627			
Operations and Maintenance	20			
Total Annual Cost	\$ 647			

TABLE E-13
RIO GUANAJIBO FEASIBILITY REPORT

SUMMARY OF BENEFITS AND COSTS ASSOCIATED WITH THE PRELIMINARY AND FINAL PLANS FOR THE
MAYAGUEZ-HORMIGUEROS AND THE SAN GERMAN AREAS
(\$1,000 of 1993)

PLANS	ANNUAL COST	INUNDATION REDUCTION BENEFITS	NET FLOODING	BENEFIT TO COST RATIO
MAYAGUEZ-HORMIGUEROS AREA				
PRELIMINARY				
1 Levee (100-Year)	\$2,649	\$5,256	\$2,607	1.98/1.0
2 Levee (100-Year)	2,393	5,256	2,863	2.20/1.0
3 Channel (100-Year)	7,555	5,256	0	0.70/1.0
FINAL				
1 Levee (50-Year)	\$2,024	\$4,773	\$2,749	2.36/1.0
2 Levee (100-Year)	2,393	5,256	2,863	2.20/1.0
3 Levee (SPF)	2,802	5,513	2,711	1.97/1.0
SAN GERMAN AREA				
PRELIMINARY				
1 Concrete Channel (100-Year)	\$2,863	\$1,245	\$ 0	0.43/1.0
2 Levee (100-Year)	1,464	1,219	0	0.87/1.0
3 Levee (25-Year)	869	878	9	1.03/1.0
4 Channel (10-Year)	647	700	53	1.08/1.0
FINAL				
1 Channel (10-Year)	\$ 647	\$ 700	\$ 53	1.08/11.0

On the basis of past experience with FEMA Detailed Survey Reports for residential structures, a 25 percent error of damage at each stage and a confidence level of 95 percent were assumed for the depth-damage relationship.

The uncertainty underlying the Mayagüez-Hormigueros damage-related economic statistics were then combined with that of the hydrology and hydraulic uncertainty estimates to establish size of the best plan from the NED point of view (limited to inundation reduction benefits resulting from residential land use for existing conditions) and the reliability of the design stage or levee height associated with the best plan expressed in terms of its probability of holding various flooding events. The results are integrated and discussed in the section of Risk Based Analysis of the Main Report.

4. Incremental analyses. Incremental analysis as last add element was performed for each of the various levee segments suggested under the most attractive final plan (Plan 2) for the Mayagüez-Hormigueros area. Table E-14 shows the costs and benefits associated with each of them. As a result of this analysis, levee sections in the vicinity of the industrial park and east of the unnamed stream at the end of the project as well as the Río Hondo improvements and Río Majagual were dropped for inclusion in the recommended plan because they are not incrementally justified. An incremental analysis as first add element for each of the levee segments will show similar results.

E. Recommended Plan

1. Description of recommended plan. As a result of the above analysis, the recommended plan for the Mayagüez-Hormigueros area therefore consists of:

- 1.19 kilometers of floodwall/levee structure for the Guanajibo Homes development. This structure would begin near the south end of the development just upstream from Highway 102 and would extend about 1,190 meters north to the end at the south end of the Caño Corazones bridge and at Highway 102. A 450 meters section of the structure adjacent to Caño Corazones up to the vicinity of the radio station will be a flood wall.
- A 1.0 kilometer floodwall south of the San José development and a 570 meters tieback levee to protect Ramírez de Arellano development. The San José development would be surrounded by two segments of a floodwall and one diagonal segment of levee that ties into existing high ground west from the development.
- A main levee that will provide flood protection to the developed areas of Buenaventura, Valle Hermoso, and San Romualdo. The levee starts on the east bank of the Río Hondo and continues southeastward for about 1.5 kilometers downstream of PR Highway 100. A short section of the main levee would connect the east side of the developed area with the Highway 100 bridge approach. A tieback levee would be required along the southeast bank of Río Hondo. This tieback levee starts where the main levee intersects the east bank of Río Hondo and extends for about 900 meters northeastward to tie into high ground just south of

TABLE E-14
RIO GUANAJIBO FEASIBILITY REPORT
INCREMENTAL ANALYSIS
MAYAGUEZ-HORMIGUEROS AREA
ANNUAL BENEFITS AND COSTS ASSOCIATED WITH VARIOUS LEVEE SEGMENTS AND CHANNEL IMPROVEMENTS
FOR THE CANDIDATE FINAL PLAN (PLAN 2)
(\$1,000 of 1993)

LEVEE SEGMENT LOCATION	DAMAGES WITHOUT PROJECT	BENEFITS	COSTS	NET BENEFIT	BENEFIT TO COST RATIO
Guanajibo Homes Development	\$ 897	\$ 815	\$218.0	\$ 597	3.7/1.0
San José, Ramírez de Arellano, and Vista Verde Developments	651	549	254.6	294.6	2.2/1.0
Cafío Maisagual Channel Improvements	50	50	111.7	-----	-----
Parcelas Castillo, Guanajibo Gardens, Industrial Area, and Río Hondo Channel Improvements	19	12	205.0	-----	-----
Buenaventura, Valle Hermoso, and San Romualdo Developments	4,114	3,825	949.7	2,875.3	4.0/1.0
Residential Structures on Highway 309	7	5	206.0	-----	-----

Highway 114. The main levee would continue upstream PR Highway 100 and extend along the south edge of PR Highway 309 for about 900 meters to the west bank of an unnamed creek.

For the San Germán area, the recommended plan consists of:

- Channel improvements and replacement of bridge on Highway 119 to provide protection against the 10-year flood. The channel would be trapezoidal with a 65 meters bottom width and gabion-lined side slopes. This plan does not include levee construction. Protection would be provided from about the vicinity of Highway 360 bridge to end about 700 meters upstream Highway 119 bridge.

Detailed description of the recommended plan for each area is presented in the Main Report. The alignment of the improvements are also display in the plates of the Main Report.

2. Cost of recommended plan. Table E-15 shows for each of the principal flood control elements of the recommended plan for the detailed study areas and for all of them together the first costs associated with their construction. These costs estimate reflects September 1994 price level. For the Mayagüez-Hormigueros area as a whole, total first cost of the recommended plan is \$18.4 million while for the San Germán area it is \$7.7 million. Total first cost of the entire recommended plan is \$26.2 million. Details of the cost estimates are in the Design and Cost Appendix.

3. Economics of the recommended plan. Table E-16 summarizes the economics of the recommended plan for each of the principal flood control elements and for all of them together. Each element is economically justified. The recommended plan for the entire Mayagüez-Hormigueros area has a total investment cost of \$19.3 million, Net National Benefits of \$3.6 million, and a 3.2/1.0 benefit to cost ratio. The corresponding figures for the San Germán area are \$8.1 million, \$0.2 million, and 1.3/1.0. The total overall recommended project has a total investment cost of \$27.4, Net National Economic Benefit of \$3.8 million, and a 2.6/1.0 benefit to cost ratio.

TABLE E-15
RIO GUANAJIBO FEASIBILITY REPORT
FIRST COST ESTIMATES OF PRINCIPAL ELEMENTS OF RECOMMENDED PLAN
(\$1,000 of September 1994)

CATEGORY OF COST	MAYAGUEZ-HORMIGUEROS AREA				SAN GERMAN AREA	TOTAL PROJECT AREA
	Guanajibo Homes	San José	Valle Hermoso/ Buenaventura	TOTAL		
Relocations	-----	-----	445.0	\$ 445.0	\$1,616.6	\$ 2,061.6
Fish and Wildlife Facilities	140.9	239.5	-----	380.4	-----	380.4
Channel and Canals	147.2	112.7	462.0	721.9	3,592.6	4,314.5
Levees and Flood Walls	2,566.4	2,384.3	5,307.8	10,258.5	-----	10,258.5
Floodway Control and Diversion Structure	-----	-----	-----	-----	122.5	122.5
Total Construction Features	2,854.5	2,736.5	6,214.8	\$11,805.8	\$5,331.7	\$17,137.5
Land and Damages	540.0	391.0	2,338.0	3,269.0	636.0	3,905.0
Miscellaneous Studies	0.8	0.8	1.7	3.3	2.1	5.4
PED	352.8	505.1	956.1	1,814.0	859.0	2,673.0
Construction Management	299.4	428.8	811.8	1,540.0	885.0	2,425.0
Total Non-Construction Items	1,193.0	1,325.7	4,107.6	6,626.3	2,382.1	9,008.4
Total First Cost	4,047.5	4,062.2	10,322.4	\$18,432.1	\$7,713.8	\$26,145.9

TABLE E-16
RIO GUANAJIBO FEASIBILITY REPORT
SUMMARY OF ECONOMICS OF PRINCIPAL ELEMENTS OF RECOMMENDED PLAN
(\$1,000 of September 1994)

	MAYAGUEZ-HORMIGUEROS AREA				SAN GERMAN AREA	TOTAL PROJECT AREA
	Guanajibo Homes	San José	Valle Hermoso/Buenaventura	TOTAL		
TOTAL FIRST COST*	4,010.6	\$4,035.3	\$10,217.3	\$18,263.2	\$7,697.3	\$25,960.5
Interest during Construction	247.4	254.5	501.9	1,003.8	400.6	1,404.4
TOTAL INVESTMENT COST	4,258.0	\$4,289.8	\$10,719.2	\$19,267.0	\$8,097.9	\$27,364.9
Annual Investment Cost	348.0	\$ 350.7	\$ 876.2	\$1,574.9	\$ 661.9	\$2,236.8
Annual Operation and Maintenance	15.0	15.0	30.0	60.0	20.0	80.0
TOTAL ANNUAL COST	363.0	\$ 365.7	\$ 906.2	\$1,634.9	\$ 681.9	\$2,316.8
Annual Benefits:						
Inundation Reduction	815.0	\$549.0	\$3,825.0	\$5,189.0	\$ 700.0	\$5,889.0
Employment	20.0	18.0	43.0	81.0	38.0	119.0
Advance Bridge Replacement	0.0	0.0	0.0	0.0	121.5	121.5
Flood Insurance Cost	1.3	1.0	3.4	5.7	0.0	5.7
TOTAL ANNUAL BENEFITS	836.3	\$ 568.0	\$3,871.4	\$5,275.7	\$ 859.5	\$6,135.2
Net NED Benefits	473.3	\$ 202.3	\$2,965.2	\$3,640.8	\$ 177.6	\$3,818.4
BENEFIT-TO-COST RATIO	2.3/1.0	1.5/1.0	4.3/1.0	3.2/1.0	1.3/1.0	2.6/1.0

*Does not include cost relating to PL 91-646 and miscellaneous studies.

